UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17

Chemical Engineering

Second Year with Effect from **AY 2017-18**
Third Year with Effect from **AY 2018-19**
Final Year with Effect from **AY 2019-20**
Under

FACULTY OF TECHNOLOGY

As per **Choice Based Credit and Grading System**
With effect from the AY 2016–17

From Coordinator's Desk

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) give freedom to affiliated Institutes to add few (PEO's) course objectives course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, developed curriculum accordingly. In addition to outcome based education, **Choice Based Credit and Grading System** is also introduced to ensure quality of engineering education.

Choice 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 not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes Faculty of Technology has devised a transparent credit assignment policy adopted ten points scale to grade learner's performance. Credit grading based system was implemented for Second Year of B.E. in Chemical Engineering from the academic year 2017-2018. This system is carried forward for Third Year of B.E. in Chemical Engineering in the academic year 2018-2019 and will be implemented for Fourth Year B.E. in the year 2019-2020 respectively.

Dr. S. K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Preamble to the Revision of Syllabus in Chemical Engineering

To match the increasing pace of development in all fields including Chemical Engineering and Biotechnology along with use of soft wares for process plant and process engineering, there is demand on academician to upgrade the curriculum in Education. The availability of free software such as Scilab expands the boundaries of learning. Hence, the Undergraduate Curriculum in Chemical Engineering must provide the necessary foundation for a Chemical Engineer to be able to specialize in any area as and when the need and opportunity arise. The Curriculum must integrate knowledge of the basic and advanced sciences with problem solving abilities and inclusion of technological development. 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 learners to carry out research and develop products to meet rapidly changing needs and demands. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program.

With these objectives, a meeting was organized at Thadomal Shahani Engineering College Bandra on 17th November 2016 which was attended by Industries experts, heads of the departments and subject faculty of affiliating Institutes. The program objectives and outcomes were thoroughly discussed in this meeting and the core structure of the syllabus was formulated keeping in mind choice based credit and grading system curriculum to be introduced in this revised syllabus for B.E. (Chemical Engineering) for all semesters. Views from experts and UG teachers were taken into consideration and final Academic and Exam scheme was prepared with the consent of all the members involved. Subject wise meetings were held to finalize the detail syllabus in Bharati Vidyapeeth College of Engineering on 13th Jan 2017, SS Jondhale College of Engineering on 27th Jan 2017, Datta Meghe College of Engineering Airoli on 20th February 2017 and 13th April 2017 and in D. J. Sanghavi College of Engineering on 17th April 2017.

The Program Educational Objectives finalized for the undergraduate program in Chemical Engineering are:

1. To prepare the student for mathematical, scientific and engineering fundamentals
2. To motivate the student to use modern tools for solving real life problems
3. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities.
4. To prepare the student in achieving excellence in their career in Indian and Global Market.

Dr. Kalpana S. Deshmukh,
Chairman, Board of Studies in Chemical Engineering (Adhoc),
University of Mumbai

General Guidelines

Tutorials

- The number of tutorial batches can be decided based on facilities available in the institution.
- Tutorials can be creative assignments in the form of models, charts, projects, etc.

Term Work

- Term work will be an evaluation of the tutorial/practical done over the entire semester.
- It is suggested that each tutorial/practical be graded immediately and an average be taken at the end.
- A minimum of eight tutorials/ten practical will form the basis for final evaluation.
- The total 25 marks for term work (except project and seminar) will be awarded as follows:

  Tutorial / Practical Journal – 20 marks

  Overall Attendance – 05

  Further, while calculating marks for attendance, the following guidelines shall be adhered to:

  75 % to 80%. – 03 marks

  81% to 90% - 04 marks

  91% onwards – 05 marks

Theory Examination

- In general all theory examinations will be of 3 hours duration.
- Question paper will comprise of total six questions, each of 20 Marks.
- Only four questions need to be solved.
- Question one will be compulsory and based on maximum part of the syllabus.

Note:

In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus as far as possible.

Practical Examination:

- Duration for practical examination would be the same as assigned to the respective Lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Project and Seminar Guidelines

- Project Groups: Students can form groups with minimum 2 (Two) and not more than 3 (Three)

- The load for projects may be calculated proportional to the number of groups, not exceeding two hours per week.

- The load for projects may be calculated as:
  Sem VII: ½ hr for teacher per group.
  Sem VIII: 1 hr for teacher per group.

- Each teacher should have ideally a maximum of three groups and only in exceptional cases four groups can be allotted to the faculty.

- Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.

- The load for seminar will be calculated as one hour per week irrespective of the number of students

- Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours each were allotted in Project A, B and three hours for Seminar to the students.

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester III (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC301	Applied Mathematics-III	3	-	1	3	-	1	4
CHC302	Engineering Chemistry I	4	-	-	4	-	-	4
CHC303	Fluid Flow Operations (FFO)	4	-	-	4	-	-	4
CHC304	Chemical Engineering Thermodynamics I	3	-	1	3	-	1	4
CHC305	Process Calculations	3	-	1	3	-	1	4
CHC306	Chemical Technology	4	-	-	4	-	-	4
CHL301	Engineering Chemistry-I Lab	-	3	-	-	1.5	-	1.5
CHL302	Chemical Engineering Lab I (FFO)	-	3	-	-	1.5	-	1.5
CHL303	Chemical Engineering Lab II (Synthesis)	-	2	-	-	1	-	1
	Total	21	8	3	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC301	Applied Mathematics-III	20	20	20	80	3	25	-	-	125
CHC302	Engineering Chemistry I	20	20	20	80	3	-	-	-	100
CHC303	Fluid Flow (FF)	20	20	20	80	3	-	-	-	100
CHC304	Chemical Engineering Thermodynamics I	20	20	20	80	3	25	-	-	125
CHC305	Process Calculations	20	20	20	80	3	25	-	-	125
CHC306	Chemical Technology	20	20	20	80	3	-	-	-	100
CHL301	Engineering Chemistry-I Lab	-	-	-	-	3	-	25	-	25
CHL302	Chemical Engineering Lab I (FFO)	-	-	-	-	3	25	25	-	50
CHL303	Chemical Engineering Lab II (Synthesis)	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester IV (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC401	Applied Mathematics-IV	3	-	1	3	-	1	4
CHC402	Engineering Chemistry II	4	-		4	-	-	4
CHC403	Chemical Engineering Thermodynamics II	3	-	1	3	-	1	4
CHC404	Solid Fluid Mechanical Operations (SFMO)	4	-	-	4	-	-	4
CHC405	Mechanical Equipment Design (MED)	4	-	-	4	-	-	4
CHC406	Chemical Engineering Economics	3	-	1	3	-	1	4
CHL401	Engineering Chemistry-II Lab	-	3	-	-	1.5	-	1.5
CHL402	Chemical Engineering Lab III (SFMO)	-	3	-	-	1.5	-	1.5
CHL403	MED Lab	-	2	-	-	1	-	1
	Total	21	8	2	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC401	Applied Mathematics-IV	20	20	20	80	3	25	-	-	125
CHC402	Engineering Chemistry II	20	20	20	80	3	-	-	-	100
CHC403	Chemical Engineering Thermodynamics II	20	20	20	80	3	25	-	-	125
CHC404	Solid Fluid Mechanical Operations (SFMO)	20	20	20	80	3	-	-	-	100
CHC405	Mechanical Equipment Design (MED)	20	20	20	80	3	-	-	-	100
CHC406	Chemical Engineering Economics	20	20	20	80	3	25	-	-	125
CHL401	Engineering Chemistry-II Lab	-	-	-	-	3	-	25	-	25
CHL402	Chemical Engineering Lab III (SFMO)	-	-	-	-	3	25	25	-	50
CHL403	MED Lab	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
T.E. Semester V (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC501	Computer programming and Numerical Methods	4	-	-	4	-	-	4
CHC502	Mass transfer Operations-I (MTO- I)	4	-	-	4	-	-	4
CHC503	Heat transfer Operations (HTO)	4	-	-	4	-	-	4
CHC504	Chemical Reaction Engineering-I (CRE I)	4	-	-	4	-	-	4
CHC505	Business Communication & Ethics	2	-	2	-	-	2	2
CHDE501X	Department Elective I	4	-	-	4	-	-	4
CHL501	Computer programming and Numerical Methods lab	-	2	-	-	1	-	1
CHL502	Chemical Engineering Lab IV (MTO-I)	-	3	-	-	1.5	-	1.5
CHL503	Chemical Engineering Lab V (HTO)	-	3	-	-	1.5	-	1.5
CHL504	Chemical Engineering Lab VI (CRE-I)	-	2	-	-	1	-	1
	Total	20	14	-	20	5	2	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC501	Computer programming and Numerical Methods	20	20	20	80	3	-	-	-	100
CHC502	Mass transfer Operations-I (MTO- I)	20	20	20	80	3		-	-	100
CHC503	Heat transfer Operations (HTO)	20	20	20	80	3		-	-	100
CHC504	Chemical Reaction Engineering-I (CRE I)	20	20	20	80	3		-	-	100
CHC505	Business Communication & Ethics	-	-	-	-	-	50	-	-	50
CHDE501X	Department Elective I	20	20	20	80	3		-	-	100
CHL501	Computer programming and Numerical Methods Lab	-	-	-	-	2	25	25	-	50
CHL502	Chemical Engineering Lab IV (MTO-I)	-	-	-	-	3	25	25	-	50
CHL503	Chemical Engineering Lab V (HTO)	-	-	-	-	3	25	25	-	50
CHL504	Chemical Engineering Lab VI (CRE-I)	-	-	-	-	2	25	25	-	50
	Total			100	400	-	150	100	-	750

Department Elective I (Sem V)		
Engineering Stream (Elective Code)	Advanced Sciences Stream (Elective code)	Technology Stream (Elective Code)
1. Piping Engineering (CHDE5011) 2. Instrumentation (CHDE5014)	1. Colloids and Interfaces (CHDE5012)	1. Advanced Material Sciences (CHDE5013)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
T.E. Semester VI (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC601	Environmental Engineering (EE)	4	-	-	4	-	-	4
CHC602	Mass transfer Operations –II (MTO-II)	4	-	-	4	-	-	4
CHC603	Transport Phenomenon	3	-	1	3	-	1	4
CHC604	Chemical Reaction Engineering –II (CRE- II)	4	-	-	4	-	-	4
CHC605	Plant Engineering & Industrial Safety	3	-	1	3	-	1	4
CHDE602X	Department Elective II	4	-	-	4	-	-	4
CHL601	Chemical Engineering Lab VII (EE)	-	3	-	-	1.5	-	1.5
CHL602	Chemical Engineering Lab VIII (MTO-II)	-	3	-	-	1.5	-	1.5
CHL603	Chemical Engineering LabIX CRE-II)	-	2	-	-	1	-	1
	Total	22	8	2	22	4	2	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC601	Environmental Engineering (EE)	20	20	20	80	3	-	-	-	100
CHC602	Mass transfer Operations –II (MTO-II)	20	20	20	80	3	-	-	-	100
CHC603	Transport Phenomenon	20	20	20	80	3	25	-	-	125
CHC604	Chemical Reaction Engineering –II (CRE- II)	20	20	20	80	3	-	-	-	100
CHC605	Plant Engineering & Industrial Safety	20	20	20	80	3	25	-	-	125
CHDE602X	Department Elective II	20	20	20	80	3	-	-	-	100
CHL601	Chemical Engineering Lab VII (EE)	-	-	-	-	3	25	25		50
CHL602	Chemical Engineering Lab VIII (MTO-II)	-	-	-	-	3	25	25	-	50
CHL603	Chemical Engineering Lab IX CRE-II)	-	-	-	-	2	25	25	-	50
	Total			120	480	-	125	75	--	800

Department Elective II (Sem VI)		
Engineering Stream (Elective Code)	Management Stream (Elective Code)	Technology Stream (Elective Code)
1. Computational Fluid Dynamics (CHDE6021)	1. Operation Research (CHDE6022)	1. Biotechnology (CHDE6023)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
B.E. Semester VII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC701	Process Equipment Design. (PED)	4	-	-	4	-	-	4
CHC702	Process Engineering	3	-	1	3	-	1	4
CHC703	Process Dynamics and Control (PDC)	4	-	-	4	-	-	4
CHDE703X	Department Elective III	4	-	-	4	-	-	4
ILO701X	Institute Elective I	3	-	-	3	-	-	3
CHP701	Project A	-	-	8	-	-	3	3
CHS701	Seminar	-	-	3	-	-	3	3
CHL701	PED Lab	-	3	-	-	1.5	-	1.5
CHL702	Chemical Engineering Lab X (PDC)	-	3	-	-	1.5	-	1.5
	Total	18	6	12	18	3	7	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC701	Process Equipment Design. (PED)	20	20	20	80	3	-	-	-	100
CHC702	Process Engineering	20	20	20	80	3	25	-	-	125
CHC703	Process Dynamics and Control (PDC)	20	20	20	80	3	-	-	-	100
CHDE703X	Department Elective III	20	20	20	80	3	-	-	-	100
ILO701X	Institute Elective I	20	20	20	80	3	-	-	-	100
CHP701	Project A	-	-	-	-	-	100		25	125
CHS701	Seminar	-	-	-	-	-	50	-	-	50
CHL701	PED Lab	-	-	-	-	-	25	-	25	50
CHL702	Chemical Engineering Lab X (PDC)	-	-	-	-	3	25	25	-	50
	Total			100	400	-	225	25	50	800

Department Elective III (Sem VII)		
Engineering Stream (Elective Code)	Management Stream (Elective Code)	Technology Stream (Elective Code)
1. Corrosion Engineering (CHDE7031)	2. Industrial organization and Management. (CHDE7032)	1.Petroleum Refining Technology(CHDE7033) 3. Food Technology (CHDE7034)

Institute Level Optional Subject I (Sem VII)		
1. Product Lifecycle Management(ILO7011)	4. Design of Experiments(ILO7014)	7. Disaster Management and Mitigation Measures(ILO7017)
2. Reliability Engineering (ILO7012)	5. Operation Research (ILO7015)	8. Energy Audit and Management (ILO7018)
3. Management Information System (ILO7013)	6. Cyber Security and Laws (ILO7016)	9. Development Engineering (ILO7019)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
B.E. Semester VIII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC801	Modeling, Simulation & Optimization (MSO)	4	-	-	4	-	-	4
CHC802	Project Engineering & Entrepreneurship Management	3	-	1	3	-	1	4
CHC803	Energy System Design	3	-	1	3	-	1	4
CHDE804X	Department Elective IV	4	-	-	4	-	-	4
ILO802X	Institute Elective II	3	-	-	3	-	-	3
CHP801	Project B	-	-	8	-	-	6	6
CHL801	Chemical Engineering Lab XI (MSO)	-	2	-	-	1	-	1
	Total	17	2	10	17	1	8	26

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC801	Modeling, Simulation & Optimization (MSO)	20	20	20	80	3	-	-	-	100
CHC802	Project Engineering & Entrepreneurship Management	20	20	20	80	3	25	-	-	125
CHC803	Energy System Design	20	20	20	80	3	25	-	-	125
CHDE804X	Department Elective IV	20	20	20	80	3		-	-	100
ILO802X	Institute Elective II	20	20	20	80	3		-	-	100
CHP801	Project B	-	-	-	-	-	100	-	50	150
CHL801	Chemical Engineering Lab XI (MSO)	-	-	-	-	2	25	25	-	50
	Total			100	400	-	175	25	50	750

Department Elective IV (Sem VIII)		
Engineering Stream (Course Code)	Management Stream (Course Code)	Technology Stream (Course Code)
1. Advanced Process Control (CHDE8041)	1. Total Quality Management (CHDE8042)	1. Advanced Separation Technology (CHDE8043) 2. Polymer Technology(CHDE8044)

Institute Level Optional Subject II (Sem VIII)		
1. Project Management (ILO8021)	4. Human Resource Management (ILO8024)	7. IPR and Patenting (ILO8027)
2. Finance Management (ILO8022)	5. Professional Ethics and CSR (ILO8025)	8. Digital Business Management (ILO8028)
3. Entrepreneurship Development and Management (ILO8023)	6. Research Methodology(ILO8026)	9. Environmental Management (ILO8029)

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester III (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC301	Applied Mathematics-III	3	-	1	3	-	1	4
CHC302	Engineering Chemistry I	4	-	-	4	-	-	4
CHC303	Fluid Flow Operations (FFO)	4	-	-	4	-	-	4
CHC304	Chemical Engineering Thermodynamics I	3	-	1	3	-	1	4
CHC305	Process Calculations	3	-	1	3	-	1	4
CHC306	Chemical Technology	4	-	-	4	-	-	4
CHL301	Engineering Chemistry-I Lab	-	3	-	-	1.5	-	1.5
CHL302	Chemical Engineering Lab I (FFO)	-	3	-	-	1.5	-	1.5
CHL303	Chemical Engineering Lab II (Synthesis)	-	2	-	-	1	-	1
	Total	21	8	3	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC301	Applied Mathematics-III	20	20	20	80	3	25	-	-	125
CHC302	Engineering Chemistry I	20	20	20	80	3	-	-	-	100
CHC303	Fluid Flow (FF)	20	20	20	80	3	-	-	-	100
CHC304	Chemical Engineering Thermodynamics I	20	20	20	80	3	25	-	-	125
CHC305	Process Calculations	20	20	20	80	3	25	-	-	125
CHC306	Chemical Technology	20	20	20	80	3	-	-	-	100
CHL301	Engineering Chemistry-I Lab	-	-	-	-	3	-	25	-	25
CHL302	Chemical Engineering Lab I (FFO)	-	-	-	-	3	25	25	-	50
CHL303	Chemical Engineering Lab II (Synthesis)	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

Course Code	Course/Subject Name	Credits
CHC301	Applied Mathematics III	4

Pre-requisites:

- Basics of Complex numbers, Modulus, Argument, Equation of circle, Roots of unity, Euler's formula, Hyperbolic functions, Matrices, Symmetric, Orthogonal and Unitary matrices, Rank, Normal form, Solution of system of linear equations, L. I. & L. D. vectors, Basics of Probability.

Course Objectives:

- To enable students to solve initial value ODE problems using L-transforms.
- To strengthen the knowledge of students in Linear Algebra.
- To study the basics of statistics and Probability.
- To study the basics of Complex Variable.

Course outcomes:

- The student will be able to apply Laplace Transform techniques for solving initial value problems.
- Identify the Analytic function and Harmonic function and to apply Bilinear Transformation.
- Understanding and apply the concept of Probability distribution and Sampling theory to engineering problems.

Module	Topics	Contact hours
1	**Laplace transform:** 1.1 Introduction, Definition of Laplace transform, Laplace transform of constant, trigonometrical, exponential functions. 1.2 Important properties of Laplace transform: First shifting theorem, Laplace transform of L{ $f(at)$ }, L{ $t^n f(t)$ }, L{ $\frac{f(t)}{t}$ }, L{ $\frac{d^n f(t)}{dt^n}$ }, L{ $\int_0^t f(u)du$ }, without proof. 1.3 Unit step function, Heavi side function, Second shifting theorem, Dirac-delta function, Periodic function and their Laplace transforms without proof. 1.4 Inverse Laplace transform with Partial fraction and Convolution theorem. (without proof) 1.5 Application to solve initial and boundary value problem involving ordinary differential equations with one dependent variable and constant coefficients.	10
2	**Matrices:** 2.1 Eigen values and eigen spaces of 2x2 and 3x3 matrices; existence of a basis and finding the dimension of the eigen space (no proofs); diagonalisable matrices. 2.2 Cayley - Hamilton theorem. (without proof)	08

	2.3 Quadratic forms; orthogonal and congruent reduction of a quadratic form in 2 or 3 variables; rank, index, signature; definite and indefinite forms.	
3	**Probability:** 3.1 Random Variables:- discrete & continuous random variables, expectation, Variance, Probability Density Function & Cumulative Density Function. 3.2 Moments, Moment Generating Function. 3.3 Probability distribution: binomial distribution, Poisson & normal distribution.	**07**
4	**Sampling Theory:** 4.1 Test of Hypothesis, Level of significance, Critical region, One Tailed and two Tailed test, Test of significant for Large Samples:-Means of the samples and test of significant of means of two large samples. 4.2 Test of significant of small samples:- Students t- distribution for dependent and independent samples. 4.3 Chi square test:- Test of goodness of fit and independence of attributes, Contingency table. **Correlation:** 4.4 Karl Pearson's coefficient of correlation, covariance, Spearman's Rank correlation. 4.5 Regression Lines.	**07**
5	**Complex Variable:** 5.1 Functions of a complex variable, Analytic functions, Cauchy-Riemann equations in Cartesian co-ordinates, Polar co-ordinates. (without proof) 5.2 Harmonic functions, Analytic method and Milne Thomson methods to find f(z), Orthogonal trajectories. (without proof) **Mapping** 5.3 Conformal Mapping, Linear, Bilinear transformations, Cross ratio, fixed points and standard transformation such as rotation and magnification, invertion, translation.	**07**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference Books

1. Higher Engineering Mathematics by Dr. B. S. Grewal 42th edition, Khanna Publication.
2. Advanced Engineering Mathematics by Kreyszig E. 9th edition, John Wiley.
3. A Text Book of Applied Mathematics Vol. II by P.N.Wartilar & J.N.Wartikar, Pune, Vidyarthi Griha Prakashan., Pune.
4. Advanced Engg. Mathematics by C. Ray Wylie & Louis Barrett. TMH International Edition.
5. Mathematical Methods of Science and Engineering by Kanti B. Datta, Cengage Learning.
6. Laplace Transforms by Murry R. Spieget, Schaun'sout line series-McGraw Hill Publication.
7. Theory And Problems of Statistics by Murry R. Spieget, Schaun'sout line series-McGraw Hill Publication.
8. Fundamentals Of Mathematical Statistics by S. C. Gupta, V. K. Kapoor, Sultan Chand & Sons -2003

Course Code	Course/Subject Name	Credits
CHC302	Engineering Chemistry– I	4

Prerequisites:

- Knowledge of Vander-Waal's forces, various bonds, Octet rule, Resonance theory, Hybridization.
- Knowledge of variable valency, ligands.
- Knowledge of properties of transition metals.
- Knowledge of intermediate steps involved in conversion of reactants to products.
- Basic concept of quantum chemistry & wave theory approach.

Course Objectives:

- To understand chemical bonding.
- To study chelation and its advantages.
- To understand structures of different bio-molecules and their chemistry.
- To study importance of iron compounds for life.
- To understand different concepts of organic reactions.
- To study the effect of temperature and time on chemical reactions.
- To become aware of industrially important reactions.
- To understand mechanism of aromatic substitution and elimination reactions.

Course Outcomes:

- Students will understand different theories of chemical bonding, organo metallic chemistry, mechanism and application of Photochemical processes.
- Students will also be capable of defining Stability of Coordination compounds, Kinetics and energy profile diagrams of reactions.
- Students will have knowledge of metal carbonyls and their properties.
- Students will able to express role of metallo proteins in biological processes.
- Students will be able to carry out organic estimations, gravimetric analysis and handle different instruments in the laboratory.

Module	Content	Contact Hours
1	**Basic Concepts of Chemistry and Molecular Structures-** Hydrogen bonding, Valence bond theory (application for H_2 molecule). Molecular orbital theory, Bonding, Non-bonding and anti-bonding orbitals, LCAO method, VSEPR theory .Structure of BrF_3, SF_4, XeF_4, and IF_7. Molecular orbital diagrams of homonuclear and hetero nuclear molecules H_2, Be_2, B_2, C_2, N_2, O_2, F_2,HF CO,NO and NO^+ types etc, metallic bond.	08

2	**Co-ordination chemistry** Definitions- Co-ordination number or ligancy, Ligand, Complex ion, Co-ordination or dative bond. Nomenclature and isomerism (Only Geometrical and Structural) in co-ordination compounds with respect to co-ordination number 4 and 6. Theories of coordination compounds- Werner's Co-ordination theory, Valence bond theory, Crystal field theory (CFT), Ligand field theory. Effective Atomic Number (EAN), Application of CFT to tetrahedral and octahedral complexes, drawbacks of CFT. Measurement of CFSE (10Dq), and Numericals based on EAN and 10Dq measurement.	**08**
3	**Organometallic compounds and Bio-inorganic chemistry** Chemistry of Fe-Carbonyls –Fe $(CO)_5$,$Fe_2(CO)_9$ w.r.t preparation, properties, structure and bonding. Biochemistry of proteins containing Fe and Zn. O_2 atom transfer reactions of bio molecules containing Fe.	**06**
4	**Reaction Mechanism & Reactive Intermediates** Transition state (T.S.), Intermediate, Difference between T.S. & intermediate. Equilibrium (Thermodynamically) controlled & rate (Kinetically) controlled reactions. Explain w.r.t. Nitration of chlorobenzene, methylation of toluene by Friedel-Craft's reaction, sulphonation of naphthalene.	**07**
5	**Reactive intermediates** Definition, carbocation, carbanion, carbon free radicals and carbenes – their formation, structure & stability. Reactive intermediate formation with mechanism and applications- Carbocation – Pinacol - Pinacolone reaction. Carbanion – Michael reaction. Free radical - Wohl-Ziegler bromaination reaction. Carbene - Reimer-Tiemann reaction.	**08**
6	**Photochemistry** Introduction, difference between Photochemical and thermo chemical reaction, laws of Photochemistry i) Grothus Draper Law ii) Stark Einstein Law. Fluorescence and phosphorescence. Jablonskii diagram, Quantum yield, reasons for high quantum yield. **Photochemical reactions of carbonyl compounds**-(i) Norrish type- I cleavage (ii) Norrish type-II cleavage with mechanism.	**08**

Assessment

Internal:

Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.

- Total 4 questions need to be solved.
- Question No.1 should be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Principles of Inorganic Chemistry- Puri, Sharma, Kalia – Milestone/Vishal Publishers
2. Advanced Inorganic Chemistry – J. D. Lee
3. Organic Chemistry - I L Finar volume I and II.
4. Advanced Organic Chemistry – Jerry March, John Wiley & Sons (Wiley India)
5. Organic Chemistry – J. Clayden, Greeves, Warren, Wothers. Oxford
6. Organic reaction Mechanisms- V.K. Ahluwalia , Rakesh Parashar, Narosa Publication
7. A textbook of Physical Chemistry - Glasston Samuel, Macmillan India Ltd. (1991)
8. Inorganic Chemistry: Huheey.
9. Principles of Physical Chemistry- B. R. Puri, L. R. Sharma, M.S. Pathania.
10. Photochemistry and Pericyclic Reactions- Jagdamba Singh, Jaya Singh
11. Organic reaction mechanism – Peter sykes
12. Vogel's Textbook of Practical organic chemistry.

Course Code	Course/Subject Name	Credits
CHC303	Fluid Flow Operation	4

Prerequisites:

- Students are assumed to have adequate background in physics, units and dimensions and thermodynamics.

Course Objectives:

- Students should be able to understand the scope of the subject in chemical industry.
- They should be comfortable with measurement of pressure or pressure drop.
- They should be able to calculate pressure drop and flow rates in conduits for incompressible as well as compressible fluids.
- They should be able to determine viscosity using different methods such as Stokes Law, Capillary viscometer.
- They should be able to calculate power requirement in agitation and to be able to select and calculate power requirement for pumps.
- They should be able to select proper valves.

Course Outcomes:

- After studying this subject, students would be able to measure pressure drop, flow rates etc.
- Students will able to understand basic concepts and pressure measurement.
- Students will able to understand kinetics and rheological behaviour of fluid flow.
- Students will able to understand flow equations for compressible and incompressible flow.
- Students will able to select pumps and valves and would be able to calculate power requirement for pumping as well as agitation operations.

Module	Contents	Contact Hours
1	**Introduction and Basic Concepts:** Scope and Applications of fluid flow, Properties of fluids such as Density, viscosity, surface tension, capillarity effect, vapour pressure. **Pressure and Fluid Statics:** • Fluid Pressure at a Point, Pascal's Law, Pressure Variation in a fluid at rest. Hydrostatic Equilibrium. • Measurement of Pressure, Manometers – Peizometers, U-Tube, Single Column manometer, U – Tube differential manometer, Inverted Differential U – tube manometer, inclined manometer.	7

2	**Fluid Kinematics:** • Types of fluid flow namely steady and unsteady, Uniform and non- uniform, laminar and turbulent, compressible and incompressible internal and external, one, two dimensional flow. • Newton's Law of Viscosity, Rheological behaviour of fluid, capillary viscometer.	**2**
3	**Basic Equations of Fluid Flow:** • Bernoulli's equation Euler's Equation, Modified Bernoulli's equation. • Major and Minor losses, Equivalent length, flow through pipe in series, parallel, pipe network. **Practical Application of Bernoulli's Equation:** • Venturimeter: Horizontal and inclined, Orificemeter, Pitot tube • Notches and Weirs: Introduction, classification, Derivation for V – notch, Rectangular notch.	**10**
4	**Flow through Pipes:** **A] Incompressible flow:** Shear stress distribution and velocity distribution. Relationship between Skin friction and wall shear, friction factor, Darcy-Weisbach equation. Reynolds experiment and Reynolds no., Formation of Boundary. **Laminar Flow:** Shear stress, velocity distribution, Derivation of local velocity, maximum velocity, average velocity, Kinetic Energy Correction factor, Hagen – Poiseullie equation. **Turbulent Flow:** Velocity distribution equations, Average velocity, local velocity, maximum velocity, kinetic energy correction factor (No Numericals on universal velocity). Von Carmanequation and friction factors, Moody diagram. Equivalent diameter for circular and non-circular ducts. Pipes in series and parallel. Frictional Losses in different pipe fittings. **B] Compressible Fluids:** Introduction, Mach no, Sonic, supersonic and subsonic flow, continuity equation and Bernoulli's equation, stagnation properties, Acoustic velocity. Adiabatic Flow. Isothermal Flow. Isentropic Flow.	**12**
5	**Flow past immersed bodies:** Drag forces, Coefficient of drag, Terminal settling velocity, Stoke's law.	**2**
6	**Pumps, Valves and Agitators:** Classification and types, Centrifugal pumps – Construction and working, Power required, Definitions of heads and efficiency, NPSH, Priming, Cavitations, characteristic curves. Specific	**12**

	speed, minimum speed. **Reciprocating Pump:** Classifications and working. **Power Consumption in Agitation:** Power curves, Power No., types of impellers. **Introduction to Compressors, Fans and Blowers**. **Types of Valves:** Globe valves, Gate valves, butterfly valves and non – Return valves.	

Assessment

Internal:

Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.
2. Okiishi, Huebsch, Rothmayer Munson, Fluid Mechanics - SI Version, Wiley, 7 edition, 2015.
3. Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1 and 2.
4. Suresh Ukarande, Fluid Mechanics and Hydraulics, Ane Books, 2012.
5. Robbert W. Fox, Philip J. Pritchard, Alan T. McDonald, Introduction to Fluid Mechanics, 7th edition, WILEY, India Edition.
6. Yunus A. Cengel, John M. Cimbala, Adapted by S. Bhattacharya, Fluid Mechanics Fundamentals and Applications, The McGraw Hill Companies.
7. Dr. R. K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications Pvt. Ltd.
8. Fluid Mechanics for Chemical Engineers by Noel de Nevers, McGraw Hill Education

Course Code	Course/Subject Name	Credits
CHC304	Chemical Engineering Thermodynamics I	04

Prerequisites:

- Basic thermodynamic properties, laws and equations.
- Engineering Mathematics: Differential Equations, Linear Algebraic Equations.

Course Objectives:

- To make students understand the Laws of Thermodynamics and Basics of Chemical Engineering Thermodynamics
- To make students learn to apply the concepts of Chemical Engineering Thermodynamics to various Chemical Engineering Processes

Course Outcomes:

- The students will be able to apply thermodynamic laws and equations to various Chemical Engineering processes.

Module	Contents	Contact Hours
01	• First Law of Thermodynamics for flow and non-flow processes • Calculation of heat and work for various types of processes	08
02	• Second Law of Thermodynamics • Concepts of heat engine, heat pump and refrigerator • Carnot Cycle and Carnot Principle • Clausius Inequality • Concept of Entropy and estimation of Entropy change of various processes • Third Law of Thermodynamics	08
03	• Concept of Exergy, Exergy Balance • Steady flow Exergy equation and its application	06
04	• Equations of State for non-ideal gases: Virial equation of state, van der Waals equation of state, Redlich-Kwong, Redlich-Kwong-Soave and Peng-Robinson equation of state	06
05	• Maxwell Equation, Joule Thomson effect • Enthalpy and Entropy departure functions (vander Waals and Redlich Kwong EOS) • Thermodynamic Charts, Diagrams and their applications • Fugacity and fugacity coefficient(vander Waals and Redlich Kwong EOS)	08

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks

Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. Introduction to Chemical Engineering Thermodynamic by J.M. Smith, H.C. Van Ness, M.M. Abbott, Latest Edition, McGraw Hill Publishing Company Limited
2. A textbook of Chemical Engineering Thermodynamics by K.V. Narayanan, Latest Edition, Prentice Hall of India Private Limited
3. Chemical Engineering Thermodynamics by Y.V.C. Rao, Latest Edition, University Press
4. Fundamentals of Engineering Thermodynamics by Micheal J Moran , Howard N Shaprio, Latest Edition, Wiley publication.
5. Introduction to Chemical Engineering Thermodynamics by Gopinath Halder, PHI learning Pvt. Ltd

Course Code	Course/Subject Name	Credits
CHC305	Process Calculations	4

Prerequisites:

- Linear algebra.
- Differential equations

Course Objectives:

- Students will learn to write mass balances on various process equipments with and without recycle.
- Students will learn to write energy balances on various process equipments with and without recycle.
- Students will learn to write mass and energy balances for chemical reactions with and without recycle.
- Students will learn to flow sheeting calculations.

Course Outcomes:

- Students will learn to calculate mass and energy flow rates into and out of various process equipments.
- Students will learn to calculate conversion, selectivity etc for various reactions with and without recycle.
- Students will learn to carry out degrees of freedom analysis for various units.

Module	Contents	Contact Hours
1	Introduction. Basic Chemical Calculations .Units And Dimensions Various systems of units, conversion of units. Density, specific volume, specific gravity, Concentration & composition of mixtures and solutions. Ideal Gas law, Dalton's law, Amagat,s law, Raoult's law, Henry's law	06
2	Material Balance without chemical reactions. General material balance equation, degree of freedom analysis for individual units, solving material balance problems for various unit operations using steady state equation, Material Balance for Unsteady Processes. Recycle, Bypass and Purge Calculations.	07
3	Material Balance with chemical reactions. Concept of limiting and excess reactants, conversion and yield, selectivity and degree of completion of reaction, material balance problems related to chemical reactions including recycle, bypass and purge Calculations.	07
4	Energy Balance. Heat capacity, sensible heat, latent heat, calculation of enthalpy changes. General energy balance equation. Energy balances for process involving chemical reaction including adiabatic reactions & combustion processes	10

	(Orsat Analysis & Net, Gross Calorific Value determination).	
5	Combined Material and Energy balance. Material and Energy balance for binary distillation, combustion and evaporation.	**08**

Tutorials

1. Basic chemical calculations.
2. Material balance without chemical reaction.
3. Material balance without chemical reaction for unsteady. Bypass, recycle and purge operations
4. Material balance without chemical reaction for unsteady. Bypass, recycle and purge operations.
5. Energy balance based on heat capacity, enthalpy change.
6. Energy balance based on Hess's law, temperature of reaction.
7. Energy balance based on orsat analysis, NCV and GCV.
8. Combined material and energy balance.

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Text Books

1. Narayan, K. V. and Lakshmikutty, B. "Stioichiometry and Process Calculations", 1st edition, Prentice Hall of India Pvt. Ltd., New Delhi (2006)
2. Bhatt, B. I. and Thakore, S. B., "Stoichimetry, 5th editionTata McGraw Hill Education Private Limited, New Delhi
3. Ch. Durga Prasad Rao and D. V. S. Murthy, " Process Calculations for Chemical Engineers", McMilan India Ltd. (2010)
4. O. A. Hougen, K. M. Watson, and R. A. Ragatz., "Chemical process principles-part 1, Material and Energy Balances". Second Edition. John Wiley & Sons, Inc., New York (1954). 525 pages.

Reference books

1. Himmelblau, D. M. and Riggs, J. B., "Basic Principles and Calculations in Chemical Engineering, 7th edition, Prentice Hall of India Pvt. Ltd., New Delhi (2009)
2. Stoichiometry and Process calculations by K.V. Narayanan and B. Lakshmikutty, PHI learning Pvt. Ltd

Course Code	Course/Subject Name	Credits
CHC306	Chemical Technology	4

Prerequisites

- Knowledge of Inorganic, Organic and Physical Chemistry, Physics and Mathematics.

Course Objectives

- To give students an insight of different chemical processes.
- To understand the development of a process from its chemistry.
- To understand different engineering problems in process industries.

Course Outcomes

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

- Describe various manufacturing processes used in the chemical process industries.
- Explain industrial processing and overall performance of any chemical process including the major engineering problems encountered in the process.
- Determine the overall process aspects including yield, formation of by-products and generation of waste, etc.
- Draw and illustrate the process flow diagram for a given process.

Module	Contents	Contact Hours
1	**Introduction :** Concept and brief description of the Unit Operations and Unit Processes used in Chemical Industries. **Overview of Industrially Important Products in the Chemical Process Industries:** Soaps and Detergents Dyes and Intermediates Agrochemicals	05
2	**Manufacture of Acids :** Sulphuric Acid (DCDA Process), Nitric Acid, Phosphoric Acid (Wet Process) and Acetic Acid (by reaction of carbon monoxide with methanol). **Manufacture of Fertilizers :** Ammonia, Urea and Superphosphate (SSP and TSP).	12
3	**Natural Product Industries :** Hydrogenation of Vegetable Oils Manufacture of Sugar from Sugarcane, By-products obtained in manufacture of sugar, Inversion of sugar Manufacture of ethanol by fermentation of molasses **Introduction to Biodiesel Processing :** Biodiesel production by base- catalysed transesterification process **Chloro-Alkali Industries :**	12

	Manufacture of Caustic Soda Manufacture of Hydrochloric Acid by combustion of chlorine and hydrogen Manufacture of Soda Ash (Solvay and Dual Processes)	
4	**Synthesis of Important Heavy Organic Chemicals and Intermediates :** Manufacture of Styrene by dehydrogenation of ethylbenzene Manufacture of Cumene from benzene and propylene Manufacture of Phenol from cumene by peroxidation-hydrolysis process Manufacture of Purified Terephthalic Acid (PTA) by oxidation of p-xylene	**05**
5	**Synthesis of Polymers :** Manufacture of Polyethylene : LDPE and HDPE Manufacture of Nylon 66	**03**
6	**Basic Building Blocks of Petrochemical Industry :** Introduction to Petroleum Refining Catalytic Cracking by Fluidised Catalytic Cracking Unit (FCCU) Naphtha Cracking for manufacture of ethylene and propylene Naphtha Reforming Separation of BTX (Benzene-Toluene-Xylene) Isomerization of Xylenes Separation of Xylene isomers	**08**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. Austin G.T., Shreve's Chemical Process Industries, 5th Edition, McGraw Hill International Edition.
2. Pandey, G.N., A Textbook of Chemical Technology, Vol.I and II, Vikas Publications, 1984.
3. Rao, G.N. and Sittig M., Dryden's Outlines of Chemical Technology for 21st Century, East West Press, 3rd Edition.
4. B.K. Bhaskara Rao, Modern Petroleum Refining Processes.
5. B.K. Bhaskara Rao, A Textbook of Petrochemicals.

6. Heaton, C.A., An Introduction to Industrial Chemistry, Leonard Hill, 1984.
7. Thomson, R., Modern Inorganic Chemical Industries, Royal Society of Chemistry, 2nd. Edition, 1994.
8. Kirk-Othmer's Encyclopedia of Chemical Technology, John Wiley and Sons, Inc., 4th Edition, 1990.
9. Ullmann's Encyclopedia of Industrial Chemistry, VCH, 1985.
10. McKetta's Encyclopedia of Chemical Processing and Design, Marcel Dekker, 1999.
11. Pletcher D. and Walsh, F.C., Industrial Electrochemistry, Chapman and Hall, 1990.
12. Alok Adholeya and Pradeepkumar Dadhich, Production and Technology of Biodiesel: Seeding a Change, TERI Publication, New Delhi, 2008.
13. NIIR Board of Consultants and Engineers, The complete book on Jatropha (Biodiesel) with Ashwagandha, Stevia, Brahmi and Jatamansi Herbs (Cultivation, Processing and Uses), Asia Pacific Business Press Inc.

Course Code	Course/Subject Name	Credits
CHL301	Engineering Chemistry Lab– I	1.5

List of Experiments Suggested:

Volumetric analysis-[Any 2]
Preparation of standard solutions and to find normality and deviation factor.

Titrimetric analysis- [Any 3]

- Analysis of talcum powder for Mg content by EDTA method
- Analysis of Aspirin as per I.P. or USP
- Determination of Strength of $KMnO_4$
- Determination of fluoride content in the toothpaste spectrophotometrically
- Estimation of CaO in cement
- Estimation of Vitamin C using Ceric ammonium sulphate
- Estimation of Glycine by non aqueous titration using perchloricacid

Organic estimations - [Any 2]

- Estimation of aniline
- Estimation of phenol
- Estimation of Acetamide

Gravimetric estimation - [Any 2]

- Barium as BaCl2
- Tin as SnCl2
- Nickel as Ni D.M.G.
- Zinc as ZnSO4

Preparation.

- Preparation of Methyl Salicylate

Students have to perform any 10 practicals from the above during the semester.

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
CHL302	Chemical Engineering Lab (FFO)	1.5

List of Experiments Suggested

Minimum Ten experiments must be performed

- Viscosity by Efflux time
- Reynolds Apparatus
- Bernoulli's apparatus
- Venturimeter
- Orificemeter
- Pitot tube
- V – Notch/ Rectangular notch
- Friction through Circular pipe
- Flow through Annulus.
- Flow through Helical coil
- Pipe Fitting (Minor Losses)
- Pumps
- Power Consumption in agitated vessel
- Viscosity by Stoke's Law

Term work

Term work shall be evaluated based on performance in practical.
Practical Journal: 20 marks
Attendance: 05 marks
Total: 25 marks

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
CHL303	Chemical Engineering Lab II (Synthesis)	1

s.n	Preparation	Chemicals required	Apparatus/ glassware required
1	Soap	Sodium hydroxide (20% solution), ethanol saturated solution of sodium chloride ,calcium chloride (5% solution), magnesium chloride (5% solution), ferric chloride (5% solution), cooking oil, phenolphthalein indicator solution.	250-mL beaker, 100- mL beaker; wire gauze; laboratory burner; glass stirring rod; test tubes; filter flask and Buchner funnel; filter paper; graduated cylinder
2	Alum from Aluminum	Aluminum can or aluminum metal, Crushed ice, 9M H2SO4, 1.5M KOH solution, Methanol, NaHCO3 (sodium bicarbonate)	Glass filter funnel, Buchner filter funnel, filter paper, steel wool, two 150 mL and two 150 ml beakers, 500 ml beaker, thermometer, ruler, stirring rod
3	Asprin	2 gm salicylic acid, 5.0 ml of acetic anhydride, ve drops of 85% phosphoric acid, distilled water	burette clamp, burner, stand with iron ring, wire gauze, ice bath,50 ml ask beaker, Buchner funnel aspirator
4	Methyl orange	0.29 g of anhydrous sodium carbonate, 1.0 g of sulfanilic acid monohydrate, 0.375 g of sodium nitrite, 0.7 ml of dimethylaniline and 0.5 mL of glacial acetic acid, 10% aqueous sodium hydroxide, 1.25 ml of concentrated hydrochloric acid	50 ml Erlenmeyer ask, lter,100 ml beaker, test tube
5	Thiokol rubber	Sodium hydroxide solution, 1M Sulfur 1,2-dichloroethane distilled or deionized water	Copper wire, approximately 6 inches long (15 cm); two 10 ml vials with teflon cap liners, two 400 ml beakers ,10 ml graduated cylinder ,glass pipette (dropper), hot plate, chemical resistant gloves
6	RUBBER BALL FROM RUBBER LATEX	15 ml rubber latex, 15 ml vinegar, 15 ml wate	Two paper cups (5 ounce), stir- ring rod (popsicle stick or equiv-

			alent), small bucket or large beaker (1000 ml or larger)
7	p-BROMO-NITROBENEZENE FROM BRO-MOBENEZENE	Conc. H2SO4, conc. HNO3 , bromobenzene, ethyl alcohol, conical ask, funnel, lter paper, water Bath	Conical flask, funnel, filter paper, water bath.
8	DETERGENT	Dodecanol (dodecyl alcohol), sulphuric acid, concentrated sodium hydroxide, 6M phenolphthalein solution, 1% sodium chloride	Erlenmeyer ask, 125 ml beakers, 400 ml, 150 ml, 100 ml graduated cylinders, 10 ml, 25 ml, 125 ml funnel, spatula, stirring rod, Cheese cloth, watch glass, scissors

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal: 20 marks

Attendance: 05 marks

Total: 25 marks

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2016)
S.E. Semester IV (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC401	Applied Mathematics-IV	3	-	1	3	-	1	4
CHC402	Engineering Chemistry II	4	-		4	-	-	4
CHC403	Chemical Engineering Thermodynamics II	3	-	1	3	-	1	4
CHC404	Solid Fluid Mechanical Operations (SFMO)	4	-	-	4	-	-	4
CHC405	Mechanical Equipment Design (MED)	4	-	-	4	-	-	4
CHC406	Chemical Engineering Economics	3	-	1	3	-	1	4
CHL401	Engineering Chemistry-II Lab	-	3	-	-	1.5	-	1.5
CHL402	Chemical Engineering Lab III (SFMO)	-	3	-	-	1.5	-	1.5
CHL403	MED Lab	-	2	-	-	1	-	1
	Total	21	8	2	21	4	3	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC401	Applied Mathematics-IV	20	20	20	80	3	25	-	-	125
CHC402	Engineering Chemistry II	20	20	20	80	3	-	-	-	100
CHC403	Chemical Engineering Thermodynamics II	20	20	20	80	3	25	-	-	125
CHC404	Solid Fluid Mechanical Operations (SFMO)	20	20	20	80	3	-	-	-	100
CHC405	Mechanical Equipment Design (MED)	20	20	20	80	3	-	-	-	100
CHC406	Chemical Engineering Economics	20	20	20	80	3	25	-	-	125
CHL401	Engineering Chemistry-II Lab	-	-	-	-	3	-	25	-	25
CHL402	Chemical Engineering Lab III (SFMO)	-	-	-	-	3	25	25	-	50
CHL403	MED Lab	-	-	-	-	-	25	-	25	50
	Total			120	480	-	125	50	25	800

Course Code	Course/Subject Name	Credits
CHC401	Applied Mathematics- IV	4

Prerequisites:

- The concepts of basic Mathematics as well as a few concepts of higher mathematics.
- The concepts of basic chemistry, basic civil engineering, basic mechanical engineering, etc. in order to understand the concepts like, corrosion, corrosion allowance, construction costs, equipment costs, etc.

Course Objectives:

- The Fourier Series, Fourier Transform and Partial Differential Equation
- Module does the Ground work for the techniques required to solve and find the answer for various physiochemical problems.
- To study the basics of Finite Differences.
- To study the basics of Complex Integration.
- To introduce the basics of NLPP.

Course outcomes:

- Demonstrate the ability of using Fourier Series and Fourier Transform in solving PDE.
- Enable the students to solve boundary value Problem using Finite Differences Approximations.
- Identify the applicability of theorems and evaluate the Contour Integral.
- The students will be ready for any further course on Optimization.

Module	Topics	Contact Hours
01	Fourier Series: 1.1 Orthogonal and Ortho-normal functions 1.2 Dirichlet's conditions, Fourier series of periodic functions with period 2π and $2L$. Parsevel's identities (without proof). 1.3 Fourier series for even and odd functions. 1.4 Half range sine and cosine Fourier series, 1.5 Complex form of Fourier series. 1.6 Fourier Integral Representation, sine & cosine Integrals 1.7 Fourier Transform sine & cosine transforms, complex transforms. NO PROOFS REQUIRED.	**10**
02	Partial Differential Equations: 2.1 Solutions of linear partial differential Equation by method of separation of variables 2.2 Partial differential equations governing transverse vibrations of an elastic string its solution using Fourier series. 2.3 Heat equation, steady-state configuration for heat flow.	**08**

	2.4 Two dimensional Laplace equations. (ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	
	Finite Differences and Interpolation 3.1 Forward difference operator Δ, backward difference operator ∇ , shift operator E, properties of operators Δ, ∇ and E, relation between E and D where D = $\frac{d}{dx}$. 3.2Missing terms (equal Intervals),Factorial Notation 3.3 Assumption of interpolation, Gregory Newton's Forward Interpolation formula for equal Intervals, Gregory Newton's Backward Interpolation formula for equal Intervals 3.4 Interpolation with arguments at unequal Intervals-Divided Difference table Newton's Divided Difference Formula , 3.5 Lagrange's Interpolation Formula.	**07**
04	Complex Integration 4.1 Line Integral, Cauchy's Integral theorem for simply connected regions, Cauchy's Integral formula(without proof) 4.2 Taylor's and Laurent's series (without proof) 4.3 Zeros, poles of f(z), Residues, Cauchy's Residue theorem 4.4 Applications of Residue theorem to evaluate Integrals of the type $\int_0^{2\pi} f(sin\theta, cos\theta)d\theta, \int_{-\infty}^{\infty} f(x)dx,$	**07**
05	Optimization (No theory) 5.1Non-linear programming: Lagrange multiplier method for one and two equality constraints for 2 and 3 variables, conditions on the Hessian matrix (no proof); 5.2 Non-linear programming: Kuhn-Tucker conditions with at most 2 constraints with two variables.	**07**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.

- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference Books

1. Higher Engineering Mathematics by Dr. B. S. Grewal 42th edition, Khanna Publication 2005.
2. Advanced Engineering Mathematics by Kreyszig E. 9th edition, John Wiley.
3. A Text Book of Applied Mathematics Vol. II by P.N.Wartilar & J.N.Wartikar, Pune, Vidyarthi Griha Prakashan., Pune.
4. Advanced Engg. Mathematics by C. Ray Wylie & Louis Barrett.TMH International Edition.
5. Mathematical Methods of Science and Engineering by Kanti B. Datta, Cengage Learning.
6. Lapplace Treansforms by Murry R. Spieget, Schaun'sout line series-McGraw Hill Publication.
7. Operation Research by S. D. Sharma.
8. Operation Research by ER. Prem Kumar Gupta & Dr. D. S. Hira.

Course Code	Course/Subject Name	Credits
CHC402	Engineering Chemistry– II	4

Prerequisites:

- Knowledge of electronic structure of atom and electrolytic properties and their laws.
- Basic concept of quantum chemistry & wave theory approach.
- Knowledge of intermediate steps involved in conversion of reactants to products.
- Knowledge of properties of solutions.

Course Objectives:

- To understand applications of EMF measurement.
- To understand the principles of different instrumental and chromatographic techniques.
- To state and understand Nernst distribution law in extraction.
- To be able to solve numerical on solvent extraction and ion exchange.
- To understand colloidal phenomenon and its applications.
- To be able to predict the significance of active methylene group.
- To state and understand the Huckel's rule of aromaticity and its application to aromatic hydrocarbons and heterocyclic compounds.

Course Outcomes:

- They should be able to understand the role of different conductivity cells and different tirimetric methods and solvent extractions.
- Students will be able to detect the organic and inorganic biological compound by the use of spectrophotometer.
- Students will know the colloidal phenomenon applied in food industry and pesticides.
- Students will be to identify the significance of rearrangement reactions, active methylene group.
- Students will be able to predict and synthesize different products by learning reaction mechanism.
- Students will have deep knowledge of Qualitative (Analysis) and Quantitative (estimations) methods.

Module	Content	Contact Hours
1	**Electrochemistry** Conductance, specific conductance, equivalent conductance, molar conductance. Effect of dilution and temperature on conductance. Transport number (Numerical on moving boundary method). Debye Huckel theory of strong electrolytes. Hydrogen ion concentration by glass electrode/Quinhydrone electrode. Concentration cells with and without transference w.r.t. cations. Weston Standard cells. Application of emf measurement for	08

	determination of solubility product (Ksp) of sparingly soluble salt.	
2	**Instrumental methods of Analysis** Conductometry -Principle and types of titrations - Acid-base and precipitation. Potentiometry- Principle and types of titrations –precipitation only. **Chromatography** Adsorption and partition. Study of Paper Chromatography, Thin Layer Chromatography, High Performance Liquid Chromatography (HPLC), Gas (Liquid and solid) Chromatography –Principle and their applications. **Optical Methods** (Principle, Instrumentation and applications) UV, IR, NMR spectroscopy, flame photometry.	**10**
3	**Ion exchange and solvent extraction techniques** Ion exchange resins, cation and anion exchangers. Desalination by ion exchange and separation of lanthanides. Solvent extraction. Nernst distribution law. Distribution ratio. Batch, continuous and counter current extraction. Numericals based on solvent extraction.	**06**
4	**Colloids and surfactants** Origin of charge on colloidal particles. Concept of electrical double layer-Helmholtz and stern model. Electro-kinetic Phenomenon- Electrophoresis, electro-osmosis, streaming potential and Dorn effect (Sedimentation potential). Colloidal electrolytes, Donnam Membrane equilibrium and its significance. **Catalysis-** Definition. Criteria of catalysis. Types (Homogeneous and Heterogeneous).Catalytic promoters, poisons. Negative catalysis and inhibition. Autocatalysis and Induced catalysis. Activation energy. Intermediate compound formation theory. Adsorption theory. Acid Base catalysis and mechanism. Enzyme catalysis- Characteristics and mechanism.	**10**
5	**Industrially important esters and Aromaticity** Synthesis and properties of malonic ester and acetate acetic ester. Huckel's rule of aromaticity, Aromatic character and reactions of Benzene, Naphthalene, Pyrrole, Furan, Thiophene, Pyridine.	**06**
6	**Name reactions.** Definition, meachanism and application of -Beckman rearangement, Fishcher-Indole synthesis, Favorskii reaction, Reformatsky reaction, Paal-Knorr synthesis of pyrrole, Benzil-Benzilic acid rearrangement.	**05**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Principles of Physical Chemistry- B. R. Puri, L. R. Sharma, M.S. Pathania.
2. A textbook of Physical Chemistry - Glasston Samuel, Macmillan India Ltd. (1991).
3. Physical chemistry - Castellan G.W. Addison Hesly-Haroda Student Edition(1994).
4. Instrumental methods of Analysis - Willard, Merritt, CBS publishers and Distributor.
5. Instrumental Methods of Chemical Analysis - S.M. Khopkar
6. Principle of instrumental analysis - Douglas A. Skoog
7. Organic Chemistry - I L Finar volume I and II.
8. Advanced Organic Chemistry – Jerry March, John Wiley& Sons(Wiley India)
9. Organic Chemistry – J. Clayden, Greeves, Warren, Wothers. Oxford
10. Organic reaction Mechanisms- V.K. Ahluwalia , Rakesh Parashar, Narosa Publication
11. Spectroscopy – P.S. Kalsi
12. Introduction to Spectroscopy – Pavia, lampman, Kritz.
13. Engineering Chemistry- Jain & Jain Dhanapat Rai publication.
14. Vogels Textbook of Practical organic chemistry.

Course Code	Course/Subject Name	Credits
CHC403	Chemical Engineering Thermodynamics II	04

Prerequisites:

- Engineering Mathematics, Chemical Engineering Thermodynamics-I

Course Objectives:

- To make students understand the concepts of equilibrium in phases and in chemical reactions
- To make students learn to calculate conditions and compositions of ideal and non-ideal vapor liquid equilibrium systems and of various chemical reactions at equilibria.
- To make students understand the concept of refrigerator and learn to calculate COP, power required etc. for a given duty of refrigeration

Course Outcomes

- Students learn the application of First law and second law to the problem of phase equilibrium and reaction equilibrium.
- Students learn to calculate the refrigerant flow rate for a given duty of refrigeration.
- Students learn to calculate the compressor sizes and loads for refrigeration.
- The calculation of phase equilibria and the understanding of it is a fundamental concept to design of mass transfer

Module	Contents	Contact hrs
01	• Properties of ideal mixtures and solutions • Non idealities of solutions and mixtures • Chemical potential • Activity and activity coefficients • Gibbs Duhem equations	04
02	• Partial molar properties • Properties changes of mixing • Excess properties	06
03	• Concept of equilibrium between phases • Review of Raoult's law and Henry's law • Phase diagrams for binary solutions • Vapor liquid equilibria in ideal and non-ideal solutions • Estimation of activity coefficients using van Laar equation, Margules equation, Wilson equation	10
04	• Representation of reaction stoichiometry • Concept of reaction equilibrium in single and multiple reactions • Estimation of standard enthalpy change of a reaction	10

	• Heat of reaction in a batch and continuous reactor • Estimation of standard Gibbs free change and equilibrium constantof a reaction • Estimation of degree of conversion and composition of reactor effluents • Degree of freedom for single and multiple reactions	
05	• Theory of Refrigeration • Vapor compression refrigeration system • Vapor absorption refrigeration system • Refrigeration cycle diagrams (P-V, T-S, H-S, H-X) • Estimation of COP, power of compression, refrigerant flow rate etc.	**06**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks

Attendance: 05 marks

Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. Introduction to Chemical Engineering Thermodynamic by J.M. Smith, H.C. Van Ness, M.M. Abbott, Latest Edition, McGraw Hill Publishing Company Limited
2. A textbook of Chemical Engineering Thermodynamics by K.V. Narayanan, Latest Edition, Prentice Hall of India Private Limited
3. Chemical Engineering Thermodynamics by Y.V.C. Rao, Latest Edition, University Press
4. Elementary Principle of Chemical Processes by Felder and Rousseau Latest Edition.
5. Introduction to Chemical Engineering Thermodynamics by GopinathHalder, PHI learning Pvt. Ltd

Course Code	Course/Subject Name	Credits
CHC404	Solid Fluid Mechanical Operations	4

Prerequisites:

- Fluid Flow Operations
- Engineering Mechanics
- Differential Equations

Course Objectives:

- understanding basic concept of particle size analysis and size reduction
- Understanding concept of flow through packed bed fluidization and filtration
- Understanding concept of sedimentation & gas solid separation
- Understanding concept of size enlargement, solid mixing and solid storage &conveying.

Course outcomes:

- The students would understand the concept of particle size analysis and size reduction.
- The students would understand the concept of flow through packed bed, fluidization and filtration
- The students would understand the concept of sedimentation and gas- solid separation.
- The students would understand the concept of solid mixing, solid storage & conveying, size enlargement.

Module	Contents	Contact Hours
1	Introduction- scope &application of solid fluid operation • Particle size analysis, particle size measurement and distribution • Sieve analysis • Capacity and effectiveness of screen • Screening Equipment: Vibrating screens; Grizzlier; Trommels • Size reduction of solids • Mechanism of size reduction and method of operation • Energy of size reduction • Size reduction Equipments: Jaw Crusher; Hammer Mill; Ball Mill; Roll Crusher	12
2	• Flow through packed bed • Types of packing • Flow of a single fluid through a packed bed, Ergun's equipment • Fluidization: Conditions for fluidization; Minimum	12

	fluidization velocity; Types of fluidization; Application of Fluidization; Numerical on Fluidization • Filtration: Mechanism of Filtration; Types of Filtration – constant rate & constant pressure; Filtration; Filter aids, washing of filter cake; Flow of filtrate through the cloth & cake combine; Numerical on constant pressure & constant cloth rate & combine cake. • Filters: Rotary drum vacuum filter, Plate & frame filter press	
3	• Economics of production and Growth • Sedimentation: Batch sedimentation; Kynch Theory of sedimentation; Area and Depth of thickener • Particle separation by Flotation and Elutriation • Gas solid separation Equipments: Cyclone separator- theory and derivation for minimum particle separated in cyclone separator. Fabric filter, Electrostatic precipitator	**10**
4	• Size enlargement of particles: Agglomeration & granulation Growth mechanism; Size enlargement processes • Storage of solids: Properties of particulate masses; Pressures in Bins &Silos; Jansen's equation • Conveying of solids: Belt conveyor, bucket conveyer, screw conveyer, pneumatic conveyer • Solid mixing: Introduction to solid mixing, degree of mixing, mixing Index & rate of mixing; Mixing Equipments:1) Mixers for cohesive solids: Muller Mixer; Kneaders . 2) Mixers for free flowing solids: Ribben Blender; Internal Screw mixer	**10**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Unit operations of Chemical engineering, WC McCabe & J C Smith, McGraw Hill
2. Chemical Engineering, Vol II J M Coulson & J F Richardson, pergamon Press
3. Unit operations by foust
4. Perry's Handbook for chemical Engineers, Robert H. Perry & Don W. Green, 8th edition, McGraw Hill

Course Code	Course/Subject Name	Credits
CHC405	Mechanical Equipment Design (MED)	4

Prerequisites:

- Fundamentals of units
- Elementary theory of engineering mechanics
- Engineering drawing

Course Objectives:

- To understand the basics for design as per the codes & standards for the mechanical design of equipments used in the process industry.
- Selection of material of construction and stress analysis by determining values of stresses arising out of different loading conditions.

Course Outcomes:

- Students will demonstrate ability to design various components of process equipment as heads, shell, flanges and supports and complete design of chemical equipment
- Students will demonstrate understanding of design of storage vessel
- Students will demonstrate general understanding of fabrication techniques and equipment testing as a designer.

Module	Contents	Contact Hours
1	Introduction to Chemical process equipment design. Nature of process equipment, General design procedure. Basic consideration in process equipment design, Standards, codes & their significance, equipment classification & selection. Fundamentals of various stresses due to compression, tension, bending, torsion& thermal stresses. Fundamental of bending moment and shear stress. Concept of moment of inertia. Calculating moment of inertia for I, T, circle and solid bar. Calculation of bending moment of cantilever and simply supported beam and uniform distributed load. Principal stress and theories of failure. Concept of hook's law, material behavior and poison's ratio, material of construction for chemical process equipment, Design pressure, Design temperature, design stress & design loads, Significance of factor of safety and economic considerations.	6
2	Design of Unfired Pressure Vessels Type of pressure vessels, code & standard for pressure vessels (IS: 2825:1969). Material of Construction, Selection of corrosion Allowance & weld joint efficiency.Thin cylinder theory for internal pressure. PART A: Pressure Vessel Subjected to Internal Pressure. Complete design of cylindrical pressure vessel as per IS: 2825: 1969. Study, selection & design of various heads such	10

	as flat, hemispherical, torispherical, elliptical & conical openings/nozzles & manholes etc. Flanged joints. Gasket: Types, selection & design. Bolt design & selection. Flange dimensions & optimization for bolt spacing. PART B: Pressure Vessel Subjected to External Pressure. Design of shell, heads nozzles, flanged joints & stiffening rings as per IS 2825: 1969 equation. Appendix F by use of charts. Analytical approach by elastic bucking & plastic deformation.	
3	Study of Various types of storage vessels and application. Atmospheric vessels, vessels for storing volatile & non-volatile liquids. Storage of gases, Losses in storage vessel. Various types of roofs used for storage vessels. Manholes, Nozzles and mounting. Design of cylindrical storage vessels as per IS: 803 should include base plates, shell plates ,roof plate and wind girders.	**5**
4	Study of various types of agitators & their application. Baffling. Power requirement of agitators & their applications, system which includes design of shaft based on equivalent bending moment and critical speed. Design of blades & Blade assembly, key & key ways. Study of seals. Design of stuffing box and gland.	**6**
5	Introduction, Classification of reaction vessels, Material of Construction, Heating system. Material of Construction, Heating system. Design of vessel. Study & design of various types of jackets like plain and half coil.	**4**
6	Introduction & classification of support. Design of skirt Support considering stresses due to dead weight, wind load, Seismic load & period of vibration. Design of base plates, skirt bearing plate, anchor bolt and bolting chair. Introduction to bracket support. Design of saddle supports.	**5**
7	Fundamentals of pipeline design. Optimum diameter of pipelines. Supporting structure for pipelines. Pipeline design for liquids and gases, steam and thermic fluids. Material of construction for pipelines.	**4**
8	Equipment fabrication and inspection Metal forming techniques (bending, Rolling, Forming). Metal Joining techniques – welding (Gas of Arc & Electric) for various types such as Butt, Lap, fillet, corner. Inspection of vessel by radiography.	**4**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.

- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Text Books

1. Process Equipment Design, 4thEdition,V.V.Mahajani, Umarji,Macmillan Publishers
2. Process Design of Equipments, 4th Edition, S.D.Dawande, Central Techno publications
3. Introduction to Chemical Equipment Design, B.C.Bhattacharya, CBS publications
4. Design of machine elements,V.B.Bhandari, McGraw Hill publications
5. Machine Drawing, N.D.Bhatt and V.M.Panchal, Charotar publication
6. Process Equipment Design and Drawing by Kiran Ghadyalji,Nandu publication. Kiran Ghadyalji, Nandu publication

Reference books

1. RC's Chemical Engineering, Fourth edition, R. K. Sinnott, Pergamon Press publications
2. Chemical Engineering Design, Fifth edition, Ray Sinnott and Cavin Towler, Elseveir, Butterworth-Heinemann publications
3. Equipment design handbook for refineries and chemical plants, volume 1 & 2,Evans F.L, Gulf publications
4. Process equipment design-vessel design, Brownell L.E., Edwin Young, John Wiley publications

Course Code	Course/Subject Name	Credits
CHC406	Chemical Engineering Economics	4

Prerequisites:

- The concepts of basic Mathematics as well as a few concepts of higher mathematics.
- The concepts of basic chemistry, basic civil engineering, basic mechanical engineering, etc. in order to understand the concepts like, corrosion, corrosion allowance, construction costs, equipment costs, etc.

Course Objectives:

- To understand various economical terms and economics related activities which can be helpful to them during economical evaluation of any chemical engineering related problem.
- To learn about various basic economic aspects like need, demand, supply, price, cost and market.
- To make familiar to calculate the interest amount on investments as well as loans by different methods
- To understand the concepts of present and future worth of property.
- To understand existing rules and regulations as well as types related to taxes and insurance.
- To understand the methodology of cost estimation including fixed and variable costs by considering the concept of cost indices.
- To have the knowledge about evaluation of depreciation cost as well as salvage value, scrap value, book value of property
- To understand the concept of profitability evaluation of project and select best process alternative based on its economic evaluation.
- To understand the concept of balance sheet, profit and loss accounting and income statement

Course Outcomes:

- Students should will be expose to market And demand driven economics in chemical industry.
- Get an idea on the growth and development of futuristic planning.
- Students will be able to calculate the profitability, rate of return on investments and cost estimation.
- After acquiring the knowledge in this subject, students become familiar with various aspects related to economics and can apply them for economic evaluation of chemical process and decide its economical feasibility.
- The knowledge in this subject will make the students well aware about economic evaluation of dissertation work that they will undertake in final year of their curriculum.
- Students will learn to prepare realistic cost estimation to prepare plan and offer.

Module	Contents	Contact hours
1	**Introduction to Basic Principles of Economics:** • Economics-various definitions • Concept of Need – hierarchy • Market - Concept of Price determination under particular market conditions – perfect competition market & monopoly market, causes • Price Discrimination-concept, types • Concept of Cost-total cost, fixed and variable cost, direct and indirect cost • Cost index – definition, types	02
2	**Demand and Supply analysis:** • Law of demand-assumptions and exceptions • Demand schedule and demand curve • Determinants of demand • Changes and variations in demand • Demand elasticity-definition, types, methods of measurement of elasticity, Income elasticity of demand, types. • Law of Supply-assumptions and exceptions • Supply schedule and supply curve • Determinants of supply, changes and variations in supply • Supply elasticity-definition, types, determinants • Methods of measurement of supply	02
3	• **Economics of production and Growth:** • Production function-types of production economies • Diseconomies of scale • Features of growth • Growth v/s Development • Determinants of growth (economic and non-economic) • Stages of growth & futuristic planning • Growth strategy- steady state and big – push growth strategy; balanced and unbalanced growth	02
4	• **Cost Accounting:** • Outline of Accounting Procedure • Basic Relationship in Accounting • Balance Sheet- types of Asset; Current and Cash Ratio • Income Statement; Debits and Credits; General format of Journal and Ledger • Methods of cost accounting 03 • Accumulation, inventory and cost-of-sales account • Material cost – Different Methods: current average, fifo, lifo	03
5	• **Interests and Investment Costs:** • Importance of time value of money- Interest and Interest	06

	rate; • Types of Interest – Simple interest (ordinary and exact), Compound interest, Nominal and Effective interest rates, Continuous interest • Present worth and Discount • Annuities, Perpetuities and Capitalized costs • Cash Flow in Chemical Project	
6	• **Taxes and Insurance:** • Concept of taxes and insurance • Types of Taxes - property tax, excise tax, income tax Capital gain tax, surtax, normal tax • Insurance types, Legal responsibilities, Self insurance • Effect of taxes and depreciation on annual income • Depreciation , types of depreciation, Methods of depreciation &Numericals	**03**
7	• **Cost Estimation:** • Cash flow to Industrial operation – Tree diagram; Cumulative Cash position • Factors affecting cost estimation; • Total, fixed, working capital investment • Breakdown of Fixed capital investment- Direct costs; Indirect costs; • Types of Capital Cost Estimates • Grass Root plant; Battery limit; • Estimation of equipment cost by scaling; Components of costs in FCI; • Methods of Cost Estimation • Estimation of Total Product Cost; • Break even Analysis • Cost estimation to prepare offer.	**10**
8	• **Profitability, Alternative Investments & Replacements:** • Introduction; Profitability Standards; • Mathematical methods for profitability evaluation- Rate of Return on investment method , Discounted cash flow method , Net present worth method, Capitalized Cost method , Pay out period method; Advantages & Disadvantages of Different Profitability Analysis Methods and their comparison • Alternative investments • Replacement analysis • Practical factors affecting investment and replacement decisions	**11**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Peters, M. S. and Timmerhaus, K. D. , "Plant design and economics for chemical engineers", latest edition, Mcgraw Hill, New York
2. Pravin Kumar "Fundamentals of Engineering Economics" Wiley India.
3. Kharbanda, O. P. and Stallworthy, E. A. "Capital cost estimating for process industries", Butterworths, Londen
4. K. K Dewett and Adarshchand, " Modern Economic Theory", latest edition, S Chand and Company
5. O. P Khanna, "Industrial Engineering and Management" Dhanpat Rai Publications (P) Ltd.
6. AtulSathe, Shubhada Kanchan, "Chemical Engineering Economics", Vipul Prakashan, Mumbai
7. Indrajit N. Yadav, "Chemical Engineering Economics" Sai- publication,Pune 2nd edition, 2017

Course Code	Course/Subject Name	Credits
CHL401	Engineering Chemistry Lab– II	1.5

List of Experiments Suggested:

- **Organic spotting-** Identification of organic compounds [**at least 05]**.
- **Potentiometric Titrations**
- Titration of strong acid and strong base potentiometrically.
- Determination of solubility and solubility product of AgCl.
- **pH-metry.**
- Determination of dissociation constant of dibasic organic acids such as malonic acid, succinic acid.
- **Conductometric Titrations.**
- Titration of strong acid with strong base.
- Weak acid against strong base.
- Titration of mixture of weak acid and strong acid against strong base.
- **Flame photometry.**
- Determination of Na / K / Ca present in the given sample.
- **Chromatography.**
- Estimation of Sodium by Ion Exchange chromatography.
- Paper Chromatography and TLC [Demonstration of techniques].
- **Organic Estimations.**
- Estimation of Glucose Iodometrically.
- Estimation of Ester by Hydrolysis.
- Volume strength and amount of H_2O_2.
- **Organic preperations**
- Nitration of benzene
- Nitration of Salicylic Acid
- Sulphonation of Benzene

Students have to perform any 10 practicals from the above during the semester.

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
CHL402	Chemical Engineering Lab III (SFMO)	1.5

List of Experiments Suggested

Minimum Ten Experiments must be performed

1. Sieve Analysis
2. Effectiveness Of Screen
3. Size reduction by Jaw Crusher
4. Size reduction by Hammer Mill
5. Size reduction by Ball Mill
6. Batch Sedimentation
7. Flow through Packed Bed
8. Flow through Fluidized Bed
9. Filtration
10. Mixing
11. Cyclone Separator
12. Roll Crusher
13. Elutriation
14. Froth Floatation

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal:	20 marks
Attendance:	05 marks
Total:	**25 marks**

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
CHL403	MED Lab	1

Drawing sheets based on (Minimum of 8 sheets):

1. Design of Unfired Pressure Vessel with internal pressure.
2. Design of Unfired Pressure Vessel with external pressure.
3. Storage Vessel.
4. Agitator.
5. Reaction Vessel.
6. Vessel Supports.

Term work

Term work shall be evaluated based on performance in Lab.

Drawing Sheets: 20 marks

Attendance: 05 marks

Total: 25 marks