

# 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 softwares for process plant and process engineering, there is demand on academicians to upgrade the curriculum in Education. The availability of free software such as Scilab, DW SIM expand 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 17<sup>th</sup> 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 13<sup>th</sup> Jan 2017, SS Jondhale College of Engineering on 27<sup>th</sup> Jan 2017, Datta Meghe College of Engineering Airoli on 20<sup>th</sup> February 2017 and 13<sup>th</sup> April 2017 and in D. J. Sanghavi College of Engineering on 17<sup>th</sup> 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 IV (w.e.f 2017-2018)**

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			Total
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	
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
	<b>Total</b>	<b>21</b>	<b>8</b>	<b>2</b>	<b>21</b>	<b>4</b>	<b>3</b>	<b>28</b>

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
	<b>Total</b>			<b>120</b>	<b>480</b>	<b>-</b>	<b>125</b>	<b>50</b>	<b>25</b>	<b>800</b>

**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			Total
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	
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
	<b>Total</b>	<b>21</b>	<b>8</b>	<b>2</b>	<b>21</b>	<b>4</b>	<b>3</b>	<b>28</b>

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
	<b>Total</b>			<b>120</b>	<b>480</b>	<b>-</b>	<b>125</b>	<b>50</b>	<b>25</b>	<b>800</b>

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
<b>01</b>	Fourier Series: 1.1 Orthogonal and Ortho-normal functions 1.2 Dirichlet's conditions, Fourier series of periodic functions with period $2\pi$ and $2L$ . Parseval'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. <b>NO PROOFS REQUIRED.</b>	<b>10</b>
<b>02</b>	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 elastic string its solution using Fourier series. 2.3 Heat equation, steady-state configuration for heat flow. 2.4 Two dimensional Laplace equations.	<b>08</b>

	(ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	
	Finite Differences and Interpolation 3.1 Forward difference operator $\Delta$ , backward difference operator $\nabla$ , shift operator E, properties of operators $\Delta$ , $\nabla$ and E, relation between E and D where $D = \frac{d}{dx}$ . 3.2 Missing 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.	<b>07</b>
<b>04</b>	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 $\int_0^{2\pi} f(\sin\theta, \cos\theta)d\theta, \int_{-\infty}^{\infty} f(x)dx,$	<b>07</b>
<b>05</b>	Optimization (No theory) 5.1 Non-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.	<b>07</b>

### 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. Laplace 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 titrimetric 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 able 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	<b>Electrochemistry</b> 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 ( $K_{sp}$ ) of sparingly soluble salt.	
2	<p><b>Instrumental methods of Analysis</b>  Conductometry -Principle and types of titrations - Acid-base and precipitation.  Potentiometry- Principle and types of titrations –precipitation only.</p> <p><b>Chromatography</b>  Adsorption and partition. Study of Paper Chromatography, Thin Layer Chromatography, High Performance Liquid Chromatography (HPLC), Gas (Liquid and solid) Chromatography –Principle and their applications.</p> <p><b>Optical Methods</b>  (Principle, Instrumentation and applications) UV, IR, NMR spectroscopy, flame photometry.</p>	10
3	<p><b>Ion exchange and solvent extraction techniques</b>  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.</p>	06
4	<p><b>Colloids and surfactants</b>  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, Donnan Membrane equilibrium and its significance.</p> <p><b>Catalysis-</b> 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.</p>	10
5	<p><b>Industrially important esters and Aromaticity</b>  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.</p>	06
6	<p><b>Name reactions.</b>  Definition, mechanism and application of -Beckman rearrangement, Fischer-Indole synthesis, Favorskii reaction, Reformatsky reaction, Paal-Knorr synthesis of pyrrole, Benzil-Benzilic acid rearrangement.</p>	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	<ul style="list-style-type: none"> <li>• Properties of ideal mixtures and solutions</li> <li>• Non idealities of solutions and mixtures</li> <li>• Chemical potential</li> <li>• Activity and activity coefficients</li> <li>• Gibbs Duhem equations</li> </ul>	04
02	<ul style="list-style-type: none"> <li>• Partial molar properties</li> <li>• Properties changes of mixing</li> <li>• Excess properties</li> </ul>	06
03	<ul style="list-style-type: none"> <li>• Concept of equilibrium between phases</li> <li>• Review of Raoult's law and Henry's law</li> <li>• Phase diagrams for binary solutions</li> <li>• Vapor liquid equilibria in ideal and non-ideal solutions</li> <li>• Estimation of activity coefficients using van Laar equation, Margules equation, Wilson equation</li> </ul>	10
04	<ul style="list-style-type: none"> <li>• Representation of reaction stoichiometry</li> <li>• Concept of reaction equilibrium in single and multiple reactions <ul style="list-style-type: none"> <li>• Estimation of standard enthalpy change of a reaction</li> <li>• Heat of reaction in a batch and continuous reactor</li> </ul> </li> </ul>	10

	<ul style="list-style-type: none"> <li>• Estimation of standard Gibbs free change and equilibrium constant of a reaction</li> <li>• Estimation of degree of conversion and composition of reactor effluents</li> <li>• Degree of freedom for single and multiple reactions</li> </ul>	
<b>05</b>	<ul style="list-style-type: none"> <li>• Theory of Refrigeration</li> <li>• Vapor compression refrigeration system</li> <li>• Vapor absorption refrigeration system</li> <li>• Refrigeration cycle diagrams (P-V, T-S, H-S, H-X)</li> <li>• Estimation of COP, power of compression, refrigerant flow rate etc.</li> </ul>	<b>06</b>

### 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 Gopinath Halder, 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 <ul style="list-style-type: none"> <li>• Particle size analysis, particle size measurement and distribution</li> <li>• Sieve analysis</li> <li>• Capacity and effectiveness of screen</li> <li>• Screening Equipment: Vibrating screens; Grizzlies; Trommels</li> <li>• Size reduction of solids</li> <li>• Mechanism of size reduction and method of operation</li> <li>• Energy of size reduction</li> <li>• Size reduction Equipments: Jaw Crusher; Hammer Mill; Ball Mill; Roll Crusher</li> </ul>	12
2	<ul style="list-style-type: none"> <li>• Flow through packed bed</li> <li>• Types of packing</li> <li>• Flow of a single fluid through a packed bed, Ergun's equipment</li> <li>• Fluidization: Conditions for fluidization; Minimum</li> </ul>	12

	fluidization velocity; Types of fluidization; Application of Fluidization; Numerical on Fluidization <ul style="list-style-type: none"> <li>• Filtration: Mechanism of Filtration; Types of Filtration – constant rate &amp; constant pressure; Filtration; Filter aids, washing of filter cake; Flow of filtrate through the cloth &amp; cake combine; Numerical on constant pressure &amp; constant cloth rate &amp; combine cake.</li> <li>• Filters: Rotary drum vacuum filter, Plate &amp; frame filter press</li> </ul>	
<b>3</b>	<ul style="list-style-type: none"> <li>• Economics of production and Growth</li> <li>• Sedimentation: Batch sedimentation; Kynch Theory of sedimentation; Area and Depth of thickener</li> <li>• Particle separation by Flotation and Elutriation</li> <li>• Gas solid separation Equipments: Cyclone separator- theory and derivation for minimum particle separated in cyclone separator. Fabric filter, Electrostatic precipitator</li> </ul>	<b>10</b>
<b>4</b>	<ul style="list-style-type: none"> <li>• Size enlargement of particles: Agglomeration &amp; granulation Growth mechanism; Size enlargement processes</li> <li>• Storage of solids: Properties of particulate masses; Pressures in Bins &amp; Silos; Jansen's equation</li> <li>• Conveying of solids: Belt conveyer, bucket conveyer, screw conveyer, pneumatic conveyer</li> <li>• Solid mixing: Introduction to solid mixing, degree of mixing, mixing Index &amp; rate of mixing; Mixing Equipments: 1) Mixers for cohesive solids: Muller Mixer; Kneaders . 2) Mixers for free flowing solids: Ribben Blender; Internal Screw mixer</li> </ul>	<b>10</b>

#### 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, 8<sup>th</sup> 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 poisson'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, 4<sup>th</sup> Edition, V.V. Mahajani, Umarji, Macmillan Publishers
2. Process Design of Equipments, 4<sup>th</sup> 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, Elsevier, 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	<p><b>Introduction to Basic Principles of Economics:</b></p> <ul style="list-style-type: none"> <li>• Economics-various definitions</li> <li>• Concept of Need – hierarchy</li> <li>• Market - Concept of Price determination under particular market conditions – perfect competition market &amp; monopoly market, causes</li> <li>• Price Discrimination-concept, types</li> <li>• Concept of Cost-total cost, fixed and variable cost, direct and indirect cost</li> <li>• Cost index – definition, types</li> </ul>	02
2	<p><b>Demand and Supply analysis:</b></p> <ul style="list-style-type: none"> <li>• Law of demand-assumptions and exceptions</li> <li>• Demand schedule and demand curve</li> <li>• Determinants of demand</li> <li>• Changes and variations in demand</li> <li>• Demand elasticity-definition, types, methods of measurement of elasticity, Income elasticity of demand, types.</li> <li>• Law of Supply-assumptions and exceptions</li> <li>• Supply schedule and supply curve</li> <li>• Determinants of supply, changes and variations in supply</li> <li>• Supply elasticity-definition, types, determinants</li> <li>• Methods of measurement of supply</li> </ul>	02
3	<ul style="list-style-type: none"> <li>• <b>Economics of production and Growth:</b></li> <li>• Production function-types of production economies</li> <li>• Diseconomies of scale</li> <li>• Features of growth</li> <li>• Growth v/s Development</li> <li>• Determinants of growth (economic and non-economic)</li> <li>• Stages of growth &amp; futuristic planning</li> <li>• Growth strategy- steady state and big – push growth strategy; balanced and unbalanced growth</li> </ul>	02
4	<ul style="list-style-type: none"> <li>• <b>Cost Accounting:</b></li> <li>• Outline of Accounting Procedure</li> <li>• Basic Relationship in Accounting</li> <li>• Balance Sheet- types of Asset; Current and Cash Ratio</li> <li>• Income Statement; Debits and Credits; General format of Journal and Ledger</li> <li>• Methods of cost accounting 03</li> <li>• Accumulation, inventory and cost-of-sales account</li> <li>• Material cost – Different Methods: current average, fifo, lifo</li> </ul>	03
5	<ul style="list-style-type: none"> <li>• <b>Interests and Investment Costs:</b></li> <li>• Importance of time value of money- Interest and Interest</li> </ul>	06

	<p>rate;</p> <ul style="list-style-type: none"> <li>• Types of Interest – Simple interest (ordinary and exact), Compound interest, Nominal and Effective interest rates, Continuous interest</li> <li>• Present worth and Discount</li> <li>• Annuities, Perpetuities and Capitalized costs</li> <li>• Cash Flow in Chemical Project</li> </ul>	
6	<ul style="list-style-type: none"> <li>• <b>Taxes and Insurance:</b></li> <li>• Concept of taxes and insurance</li> <li>• Types of Taxes - property tax, excise tax, income tax Capital gain tax, surtax, normal tax</li> <li>• Insurance types, Legal responsibilities, Self insurance</li> <li>• Effect of taxes and depreciation on annual income</li> <li>• Depreciation , types of depreciation, Methods of depreciation &amp; Numericals</li> </ul>	03
7	<ul style="list-style-type: none"> <li>• <b>Cost Estimation:</b></li> <li>• Cash flow to Industrial operation – Tree diagram; Cumulative Cash position</li> <li>• Factors affecting cost estimation;</li> <li>• Total, fixed, working capital investment</li> <li>• Breakdown of Fixed capital investment- Direct costs; Indirect costs;</li> <li>• Types of Capital Cost Estimates</li> <li>• Grass Root plant; Battery limit;</li> <li>• Estimation of equipment cost by scaling; Components of costs in FCI;</li> <li>• Methods of Cost Estimation</li> <li>• Estimation of Total Product Cost;</li> <li>• Break even Analysis</li> <li>• Cost estimation to prepare offer.</li> </ul>	10
8	<ul style="list-style-type: none"> <li>• <b>Profitability, Alternative Investments &amp; Replacements:</b></li> <li>• Introduction; Profitability Standards;</li> <li>• 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 &amp; Disadvantages of Different Profitability Analysis Methods and their comparison</li> <li>• Alternative investments</li> <li>• Replacement analysis</li> <li>• Practical factors affecting investment and replacement decisions</li> </ul>	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, London
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 2<sup>nd</sup> 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<sub>2</sub>O<sub>2</sub>.
- **Organic preparations**
- 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 Flootation

### 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**