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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 academician 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 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 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
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		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 behavior 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:**	2

	• 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 behavior of fluid, capillary viscometer.	
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 Carman equation 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 speed, minimum speed.	**12**

	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, 7th 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 (Orsat Analysis & Net, Gross Calorific Value determination).	10

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 :** Manufacture of Caustic Soda	12

	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 Fluidized 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 perchloric acid

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