UNIVERSITY OF MUMBAI

Bachelor of Engineering

Chemical Engineering (Second Year – Sem.III& IV), Revised course

(REV- 2012)from Academic Year 2012 -13,

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

University of Mumbai

Scheme for SE: Semester-IV

Teaching Scheme

Subject Code	Subject Name	Teaching Scheme			Credit Assigned			
		Theory	Pract.	Tutorial	Theory	Pract	Tut	Total
CHC401	Applied Mathematics-IV	03	-	1.0	3.0	-	1.0	4.0
CHC402	Engineering Chemistry-II	04	-	-	4.0	-		4.0
CHC403	Chemical Engg. Thermodynamics - I	03	-	1.0	3.0	-	1.0	4.0
CHC404	Material Science &Engineering	03	-	1.0	3.0	-	1.0	4.0
CHC405	Mechanical Equipment Design (MED)	03	-	1.0	3.0	-	1.0	4.0
CHC406	Solid Fluid Mechanical Operations (SFMO)	03	-	1.0	3.0	-	1.0	4.0
CHL407	Engineering Chemistry Lab II	-	03	-	-	1.5	-	1.5
CHL408	Chemical Engg Lab (SFMO)	-	03	-	-	1.5	-	1.5
CHL409	MED Lab	-	02	-	-	1.0		1.0
Total		19	08	05	19	4.0	5.0	28

Examination Scheme

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Pract.	Oral	Total
		Internal Assessment			End Sem. Exam				
		Test 1	Test 2	Average of Test 1 and Test 2					
CHC401	Applied Mathematics-IV	20	20	20	80	25	-	-	125
CHC402	Engineering Chemistry-II	20	20	20	80	-	-	-	100
CHC403	Chemical Engg. Thermodynamics – I	20	20	20	80	25	-	-	125
CHC404	Material Science Engineering	20	20	20	80	25	-	-	125
CHC405	Mechanical Equipment Design (MED)	20	20	20	80	25	-	-	125
CHC406	Solid Fluid Mechanical Operations (SFMO)	20	20	20	80	25		-	125
CHL407	Engineering Chemistry Lab II	-	-	-	-	-	25	-	25
CHL408	Chemical Engg Lab (SFMO)	-	-	-	-	-	25	-	25
CHL409	M ED Lab	-	-	-	-	-	-	25	25
Total				120	480	125	50	25	800

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 work done over the entire semester.**
- It is suggested that each tutorial be graded immediately and an average be taken at the end.
- A minimum of ten tutorials will form the basis for final evaluation.

Theory Examination:

- In general all theory examinations will be of 3 hours duration.
- Theory examination for MED in semester IV will be of 4 hour 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& 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.
- 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.

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Course Code	Course/Subject Name	Credits
CHC401	Applied Mathematics-IV	04

Prerequisites:

- **Vector Calculus**:-Multiple Integral, Partial differentiation, basic knowledge of vectors and their products, Knowledge of spherical and cylindrical coordinate system.
- Partial Differential Equation:- Integration, Knowledge of partial derivatives.

Course Objectives:

- The syllabus/module aims to introduce the above topics (to the Learner) so as to equip the learner with mathematic tools to effectively model, analyze and find the solution of various problems in Chemical Engineering processes.
- One can use vector formation and calculus together to describe and solve many problems in two/three dimension. The Fourier Transform and PDE module does the ground work for the techniques required to solve and find the answer for various physiochemical problems.

Course Outcomes:

- It is expected that the learner will develop the proactive approach towards the selection of methods to a solution of Chemical Engineering problems coming across while studying higher level of Chemical Engineering .(Example: Flow of Liquid through Pipes/Gases etc.)

Module	Contents	No. of Hours
01	**Fourier Series** • Expansion of functions in any interval (a, b) . Half range expansion; Complex form; Parseval's identity theorem; Orthogonal and Orthonormal functions. NO PROOFS REQUIRED.	9
02	• Fourier Integrals and Fourier Transform; sine & cosine Integrals, sine & cosine transforms, complex transforms. NO PROOFS REQUIRED.	10
03	**Partial Differential Equations** • Elliptic, Parabolic & Hyperbolic Equations; Laplace's equation; One dimensional Heat & Wave Equation, Two Dimensional wave equation. (ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	10
04	**Vector Integration** • Green's Theorem in the plain; Conservative &Solenoidal Fields. Gauss Divergence Theorem, Stokes' Theorem. (ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	10

References:

- Advanced Engineering Mathematics by *Erwin Kreyszig*, 9TH Edition, Wiley India.
- Schuam's outline series in Fourier series.
- Schuam's outline series in partial differential equations.
- Partial differential equations Vol 1 by Rutherford Aris.

Course Code	Course/Subject Name	Credits
CHC402	Engineering Chemistry – II	04

Prerequisites:

- Basic Concepts of Physical Chemistry and Titration Analysis.

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.
- To understand the effect of various parameters on catalytic reactions.

Course Outcomes:

- Students will understand the concepts of electrochemistry, chromatographic methods, different analytical techniques and the application of surfactants.
- Students will be aware of the significance of active methylene group during organic synthesis and the importance of catalyst. Moreover, on the basis of Huckel's rule, students will be able to differentiate between aromatic and non-aromatic compounds.
- Students will be able to carry out solvent extractions, optical methods and handle different instruments in the laboratory.

Module	Contents	No. of Hours
01	**Electrochemistry** • Conductance, specific conductance, equivalent conductance, molar conductance. Effect of dilution and temperature on conductance. Transport number.DebyeHuckel theory of strong electrolytes. Concentration cells with and without transference w.r.t. cations. Standard cells. Use of EMF measurement and other technique for determination of solubility product, hydrogen ion concentration.	8
02	**Instrumental methods of Analysis** • **Conductometry** Principle and types of titrations - Acid-base, precipitation and complexometric. • **Potentiometr**y: Principle and types of titrations - Acid-base, precipitation and complexometric. • **AmperometryPolarography:** Methods and applications. • **Chromatography** Adsorption and partition. Study of Paper Chromatography, Thin	10

	Layer Chromatography, High Performance Liquid Chromatography, Gas (Liquid and solid) Chromatography –Principle and their applications. • **Optical Methods** (Principle, Instrumentation and applications) UV, IR, NMR, GC-MS spectroscopy, flame photometry.	
03	• **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.	9
04	• **Colloids and surfactants** • Origin of charge on colloidal particles. Concept of electrical double layer. • Helmholtzand system models. Electro-kinetic Phenomenon-Electrophoresis, electro-osmosis, streaming potential and Dorn effect (Sedimentation potential). • Colloidal electrolytes, Donnam Membrane equilibrium Colloidal electrolytes. • Emulsions O/Wand W/O types, emulsifying agents, surfactants. • Applications of surfactants in detergents, pesticide formulations and food industry.	9
05	• **Industrially important esters and Aromaticity** • Synthesis and properties of malonic ester and aceto acetic ester • Aromaticity and aromatic character, Huckel's rule of aromaticity, Aromatic character of Benzene, Naphthalene, Anthracene,Pyrrole, Furan, Thiophene, Pyridine.	7
06	• **Catalysis** • Definition. Criteria of catalysis. Types (Homogeneous and Heterogeneous). • Catalytic promoters, poisons. Negative catalysis and inhibition. Autocatalysis and Induced catalysis. Activation energy and catalysis. Intermediate compound formation theory. Adsorption theory. Acid-Base catalysis and mechanism. Enzyme catalysis. Characteristics and mechanism of enzyme catalysis.	9

References:

- Organic Chemistry - I L Finar volume I and II
- Instrumental methods of Analysis - Willard, Merritt, CBS publishers and Distributors
- Instrumental Methods of Chemical Analysis -S.M.Khopkar
- A textbook of Physical Chemistry - Glasston Samuel, Macmillan India Ltd. (1991)
- Physical chemistry - Castellan G.W.Addison Hesly-Haroda Student Edition(1994)
- Inorganic chemistry - Huheey

Course Code	Course/Subject Name	Credits
CHC403	Chemical Engineering Thermodynamics-I	04

Prerequisites:

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

Course Objectives:

- To make students familiar with the basics of Chemical Engineering Thermodynamics.
- To learn to apply 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	No. of hours
01	• Concept of System, Surrounding, Processes, Cycle, State and • Path function, heat and work interactions, reversible and irreversible processes • Concept of Internal Energy and Enthalpy • First Law of Thermodynamics • Application of First Law of Thermodynamics to various types of processes, reactive processes and cycles • Thermodynamic Analysis of Flow Processes	7
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 of reversible and irreversible processes and cycles. • Concept of Exergy and Exergy of Chemical Processes	8
03	• Ideal Gas and real gas behavior • Equation of States- Van der Waals, Berthelot, Redlich-Kwong, Soave Redlich Kwong, Virial and Peng Robinson. • Applications of above mentioned equations of states to pure fluids as well as to mixtures of gases	8
04	• Helmholtz Energy and Gibbs Energy. • Maxwell relations and various thermodynamic relations • Joule Thompson effects and estimation of Joule Thompson coefficient for gases.	8
05	• Residual Properties- Residual Enthalpy and Entropy • Thermodynamic Charts, Diagrams and their applications • Fugacity and fugacity coefficient	8

References:

- Stanley I Sandler, "Chemical and Engineering Thermodynamics", John Wiley and Sons.
- Richard M Feldar, Ronald W Rousseau, "Elementary Principles of Chemical Processes", Third Edition, Wiley publishers.
- Yunus A Cengel, Michael A Boles, "Thermodynamics- An Engineering Approach", McGraw Hill.
- K.V Narayanan, "A textbook of Chemical Engineering Thermodynamics", PHI learning.
- Rao Y.V.C, "Chemical Engineering Thermodynamics", University Press.

Course Code	Course/Subject Name	Credits
CHC404	Material Science & Engineering	4

Prerequisites:

- Crystal Structures, X Ray Diffraction, Imperfections in Solids.
- Primary & Secondary Bonding, Types of Alloys, Corrosion & its types.

Course Objectives:

- To understand the basic fundamentals of Science behind Materials on atomic scale and in bulk materials.
- To find various types of Materials and analyze how properties change due to various effects.
- To apply the above knowledge for the selection of materials for process equipments.

Course Outcomes:

- Students would have knowledge about the existence of new materials and their properties.
- The students will be able to choose appropriate material for process equipments.

Module	Contents	No. of Hours
01	• Scope of Material Science & Engineering and its importance in Chemical Engineering Course • Introduction of Standard Model of an atom; Young's Double Slit Experiment for dual nature, Wave nature of electron, Heisenberg's Uncertainity Principle, De Broglie's Wavelength, Schrodinger's Wave Equation for 1-D Time Dependent.	7
02	• Introduction to Magnetic Materials, Influence of Temperature on Magnetic Behavior, Magnetic Storage, Superconductivity • Energy Band Structures in Solids, Electrical Conduction in Ionic Ceramics & in Polymers • Light Interaction with solids, Atomic & Electronic Interactions, Optical Properties of Metals, Optical Properties of Non Metals , Opacity & Translucency in Insulators like Glass	9
03	• Iron-Carbon System, Phase diagram for Iron-Carbon System, Cooling curve of Fe, Solid Phase Fe-Fe carbide phase diagram, Development of Microstructures in Iron-Carbon alloys • Deformation of Materials & Strengthening Mechanisms • Elastic Deformation, Plastic Deformation, Mechanisms of strengthening in Metals, Recovery, Recrystallization & Grain growth • Crystal Imperfections • Theories of Failure – Fatigue (cyclic stresses, S-N Curve, Crack Theory), Fracture (Types, Principles & Mechanisms) &	10

	Creep (Types)	
04	• Polymer alloys(Difference in properties with their parent polymers) & their applications (ABS- PS, PC-PET, SAN-EPDM, PET-PS), Plastics for Packaging for food, beverages, oil & Detergents • Composites (FRP in detail) • Graphite, Ceramics, Refractories, Clay	03
05	• Mechanism & Factors influencing Corrosion • Corrosion of Ceramic Materials • Degradation of Polymers	03
06	• Factors determining choice of Materials • MOC for Process Equipments • MOC for handling chemicals (in reactor, storage vessel and transportation) like Ammonium Chloride, Sulfuric Acid, Chlorine (Dry & Wet)	07

References:

- W. D. Callister, Fundamentls of Materials Science and Engineering, Wiley
- S.D.Dawande, Process Equipment Design, Denett& Co
- Beiser-Mahajan-Choudhary, Concepts of Modern Physics, McGrawHill
- Michael Ashby-Hugh Shercliff-David Cebon, Materials- Engineering, Science, Processing and Design, BH
- M.G.Fontana, Corrosion Engineering, Tata 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 a 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 No.	Contents	No. of Hrs.
1	Introduction to Chemical process Equipment Design: 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 stress due to compression, tension, bending, torsion& thermal stresses, Principal stress and theories of failure. Concept of hook's law, material behaviour 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	4
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 as Flat, hemispherical, tori-spherical, elliptical & conical.	10

	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 Appendix F by use of charts. Analytical approach by elastic bucking & plastic deformation.	
3	Storage Vessels: 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	6
4	Agitators: Study of various types of agitators & their application, Baffling, Power requirement of agitators & their applications, system which includes design of shaft based on equivalent twisting moment, equivalent bending moment and critical speed. Design of blades & Blade assembly, key & key ways. Design of rigid flange coupling, Study of seals and design of stuffing box and gland	6
5	Reaction Vessels: Introduction, Classification of reaction vessels, Material of Construction, Heating system, Design of vessel, Study & design of various types of jackets like plain and half coil.	4
6	Vessel Supports: 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	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

References:

- Machine Drawing by N.D.Bhatt and V.M.Panchal, Charotar publication
- Process Equipment Design by M.V.Joshi and V.V.Mahajani, Macmilan India
- Process Equipment Design and Drawing by Kiran Ghadyalji,Nandu publication.
- Process Equipment Design- Vessel design by L.E.Brownell and E.H.Young,John Wiley
- Chemical Engineering Volume 6-Design by J.M.Coulson, J.F.Richardson and R.H.Sinnott,Pergamon Press.
- Pressure Vessel Handbook by Eugene F.Megyesy,Pressure vessel company

Course Code	Course/Subject Name	Credits
CHC406	Solid Fluid Mechanical Operations	04

Prerequisites

- Fluid Flow Operations
- Engineering Mechanics
- Differential Equations

Course Objectives

- Understanding basic principles of particle size measurement and distribution.
- Basic knowledge in particle technology (particle size, shape, specific surface).
- Ability to understand phenomena related to specific surface of particles.
- Understanding concepts of sedimentation, flow through packed bed, filtration.
- Ability to understand solid mixing and solid conveying.

Course Outcomes

- The student would understand the concept of particle size measurement and distribution.
- The student would understand the concept of hindered settling, sedimentation and particle mechanics.
- The student would understand the concept of solid mixing, solid storage and solid conveying.
- The student would understand the concept of filtration.

Module	Contents	No. of hours
01	• Introduction:-Scope & Application of Solid Fluid Operation. • Particle Size Analysis:-Particle Size Measurement & distribution. • Sieve Analysis Screening Equipments, Capacity & Effectiveness.	5
02	• Introduction to Size Reduction Equipments, • Their Selection & Power Requirement in Milling Operations.	5
03	• Storage & Conveying of Solids: - Introduction to Storage Solids, Bins, Hoppers & Silos. • Jensen's Equation. • Conveying of Solids: - Introduction to Conveying of Solids, Belt Conveyor, Bucket Conveyor, Pneumatic Conveyor &Elevators.	7
04	• Flow through Packed Beds:-Characteristics of Packing, Ergen's Equation, Flow of a single fluid through a packed bed, Problems of Channeling & Wetting. • Fluidization.: - Fluidization Characteristics, aggregative & particulate fluidization, Minimum Fluidization, Voidage& Minimum Fluidization Velocity, Voidage Correlation, Gas-Solid fluidization characteristics • Filtration:-Flow through Filter Cakes & Medium	9

	• Washing (Numerical), Const Rate & Pressure Filtration, Filter aids, Selection of filtration Equipment.	
05	• Particle Mechanics:-Motion of Particles in fluids, Effect of particle shape, Stokes Law, Hindered Settling. • Sedimentation: - Gravity Settling, Batch Sedimentation, Kynch Theory of Sedimentation. • Area & Depth of Thickener. • Particle Separation Based on motion of Particles through fluids:-Froth floatation & Elutriation.	9
06	• Mixing of Solids & Paste. • Gas-Solid Separation Equipment:-Fabric Filter, Cyclone Separator, Electrostatic precipitator	4

References:

- Unit Operations of Chemical Engineering, W C McCabe & J C Smith, McGraw Hill.
- Chemical Engineering, Vol. II, J M Coulson and J F Richardson, Pergamon press.
- Perry's Handbook for Chemical Engineers, Robert H. Perry & Don W. Green,8th edition, McGraw Hill.
- Unit Operations by Foust

Course Code	Course/Subject Name	Credits
CHL407	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].

- Spectro-photometry.
- Estimation of Fe^{3+} ions by Spectrophotometry.

- Organic Estimations.
- Estimation of Glucose Iodometrically.
- Estimation of Ester by Hydrolytis.
- Volume strength and amount of H_2O_2.

Course Code	Course/Subject Name	Credits
CHL408	Chemical Engineering Lab (SFMO)	1.5

List of Experiments Suggested:

- Sieve Analysis
- Effectiveness of Screen
- Size Reduction by Jaw Crusher
- Size Reduction by Hammer Mill
- Size Reduction by Ball Mill
- Batch Sedimentation
- Flow through Packed Bed
- Flow through Fluidized Bed
- Filtration
- Sigma Mixer

Course Code	Course/Subject Name	Credits
CHL409	MED Lab	1

List of Suggested Drawing Sheets

- Assembly and Detailed drawings of Machine elements like shafts, key and keyways, Fasteners, Types of welding technique and symbols.
- Assembly and Detailed drawings of Pressure vessel parts such as types of heads, Nozzle joints and flanged joints, mountings (Sight glass, Light glass, man hole etc)
- Assembly and Detailed fabrication drawings of complete pressure vessel and its parts to a recommended scale.
- Assembly and Detailed fabrication drawings of complete storage vessel and its parts to a recommended scale.
- Assembly and Detailed fabrication drawings of Agitator vessel and its parts like coupling and stuffing box to a recommended scale
- Assembly and Detailed fabrication drawings various types of reaction vessel to a recommended scale
- Assembly and Detailed fabrication drawings of various types supports to a recommended scale