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-III

Teaching Scheme

Subject Code	Subject Name	Teaching Scheme			Credit Assigned			
		Theory	Pract.	Tutorial	Theory	Pract	Tut	Total
CHC301	Applied Mathematics-III	03	-	01	3.0	-	1.0	4.0
CHC302	Engineering Chemistry-I	04	-	-	4.0	-	-	4.0
CHC303	Fluid Flow (FF)	03	-	01	3.0	-	1.0	4.0
CHC304	Computer Programming & Numerical Methods	03	-	01	3.0	-	1.0	4.0
CHC305	Process Calculations	03	-	01	3.0	-	1.0	4.0
CHC306	Chemical Engineering Economics	03	-	01	3.0	-	1.0	4.0
CHL307	Chem. Engg. Lab (FF)	-	03	-	-	1.5	-	1.5
CHL308	Engineering Chemistry Lab I	-	03	-	-	1.5	-	1.5
CHL309	Computer Programming & Numerical Methods 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					
CHC301	Applied Mathematics-III	20	20	20	80	25	-	-	125
CHC302	Engineering Chemistry-I	20	20	20	80	-	-	-	100
CHC303	Fluid Flow (FF)	20	20	20	80	25	-	-	125
CHC304	Computer Programming & Numerical Methods	20	20	20	80	25	-	-	125
CHC305	Process Calculations	20	20	20	80	25	-		125
CHC306	Chemical Engineering Economics	20	20	20	80	25	-	-	125
CHL307	Chem. Engg. Lab (FF)	-	-	-	-	-	25	-	25
CHL308	Engineering Chemistry Lab I	-	-	-	-	-	25	-	25
CHL309	Computer Programming & Numerical Methods Lab	-	-	-	-	-	25	-	25
Total				120	480	125	75	-	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.

.

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

Prerequisites:

- Basics of complex numbers: modulus, argument; equation of a circle, roots of unity, Euler's formula; hyperbolic functions; matrices: symmetric, orthogonal and unitary matrices, rank, normal form, solutions of systems of linear equations; basics of LPP: graphical method; calculus: partial derivatives, Hessian, maxima/minima of functions of 1 and 2 real variables.

Course Objectives:

- To introduce students to the basic methods of Laplace transforms.
- Laplace transforms and inverse Laplace transforms of all the standard functions.
- To enable students to solve initial value ODE problems using L-transforms.
- To study Eigen values and Eigen spaces of matrices.
- Orthogonal and congruent reduction of quadratic forms.
- Complex analysis: C-R equations, Milne-Thomson method.
- Bilinear transformations and cross-ratios.
- Complex integration and applications of the residue theorem.
- Lagrange multiplier method for 2 and 3 variables with no more than two constraints.
- To introduce the basics of optimization using Kuhn-Tucker conditions.

Course Outcomes:

- The student will be able to solve initial value ODE problems.
- The student will have a good understanding of real and complex analysis.
- The student will have a thorough grounding in matrix algebra.
- The student will be ready for any further courses on optimization.

Module	Contents	No. of Hrs.
01	The Laplace transform: Definition and properties (without proofs); all standard transform methods for elementary functions including hyperbolic functions; Heaviside unit step function, Dirac delta function; the error function; evaluation of integrals using Laplace transforms; inverse Laplace transforms using partial fractions and H(t-a); convolution (no proof).	07
02	Matrices: Eigen values and eigen spaces of 2x2 and 3x3 matrices; existence of a basis and finding the dimension of the eigen space (no proofs); non-diagonalisable matrices; minimal polynomial; Cayley - Hamilton theorem (no proof); quadratic forms; orthogonal and congruent reduction of a quadratic form in 2 or 3 variables; rank, index, signature; definite and indefinite forms.	07
03	Complex analysis: Cauchy-Riemann equations (only in Cartesian co-ordinates) for an analytic function (no proof); harmonic function; Laplace's equation; harmonic conjugates and orthogonal trajectories (Cartesian co-ordinates); to find f(z) when u+v or u - v are given; Milne-Thomson method; cross-ratio (no proofs); conformal mappings; images of straight lines and	07

	circles.	
04	Complex Integration Cauchy's integral formula; poles and residues; Cauchy's residue theorem; applications to evaluate real integrals of trigonometric functions; integrals in the upper half plane; the argument principle.	06
05	Statistics: (No theory questions expected in this module) Mean, median, variance, standard deviation; binomial, Poisson and normal distributions; correlation and regression between 2 variables.	05
06	Optimization (No theory) Non-linear programming: Lagrange multiplier method for 2 or 3 variables with at most 2 constraints; conditions on the Hessian matrix (no proof); Kuhn-Tucker conditions with at most 2 constraints.	07

References:

- Mathematical Methods in Chemical Engineering, V.G. Jenson and G.V. Jeffrey's, Academic Press, 1970.
- Laplace transforms, Murray Spiegel, Schaum's Outline Series, 1974
- Complex variables, Murray Spiegel, Schaum's Outline Series, 1964
- Linear Algebra, Murray Spiegel, Schaum's Outline Series, 1964
- Advanced Engineering Mathematics by *Erwin Kreyszig*, 9^{TH} Edition, Wiley India.

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.
- Knowledge of Inductive effect, Mesomeric effect, Resonance, Tautomerism, Hyperconjugation and bond cleavage to form reactive species. Knowledge of substitution reaction.

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 learn the basic areas in chemistry like different theories of chemical bonding, organometallic chemistry, mechanism and application of aromatic substitution, elimination reactions and the orientation of functional groups.
- Students will also be capable of defining the different basic terms related to electrochemistry, spectroscopic 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 organic estimations, gravimetric analysis and handle different instruments in the laboratory.

Module No.	Contents	No. of Hours
1	**Basic Concepts of Chemistry and Molecular Structures** • Hydrogen bonding, Valence bond-Theory, Molecular orbital theory, Non-bonding and anti-bonding orbitals, LCAO method, VSEPR theory .Structure of BF_3, PCl_3, PCl_5 and SF_4. Molecular orbital structures of homonuclear and heteronuclear molecules H_2, BF_2, B_2, C_2, N_2, O_2, F_2, CO, HF, NO_2, metallic bond.	8
2	**Co-ordination chemistry** • Co-ordination number or ligancy, Complex ion, Co-ordination dative bond complex ions. Theories of coordination compounds such as Werner's Co-ordination theory, Valence bond-Theory, Crystal field theory (CFT), Ligand field theory. Effective Atomic Number (EAN). Nomenclature and isomerism (Only Geometrical and Structural) in co-ordination compounds with respect to co-ordination number 4 and 6. Application of CFT to tetrahedral and octahedral complexes, drawbacks of CFT, MOT as applied to octahedral complexes of Fe, Measurement of CFSE (10Dq), Numericals based on EAN and 10Dq measurement, Applications of coordination compounds.	10
3	**Organometallic compounds and Bio-inorganic chemistry** • Chemistry of Fe-carbonyls with respect to preparation, properties, structure and bonding. Biochemistry of proteins containing Cu, Fe and Zn chemistry of cytochromes and their application, O_2 atom transfer reactions of biomolecules containing Fe.	07
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** • Reactive intermediates • Carbocation, carbanion, carbon free radicals and carbenes – their formation, structure & stability. • Name reactions with mechanism w.r.t. each reactive intermediate. Carbocation – Pinacol - Pinacolone reaction. Carbanion – Michael reaction. Free radical - Wohl-Ziegler bromaination reaction. Carbene - Reimer-Tiemann reaction for aldehyde.	11
6	**Substitution reactions** A. Electrophilic substitution reactions. - In monocyclic aromatic compounds - Mechanism - Orientation influence - Friedel Craft alkylation B. Nucleohilic substitution reactions. - SN1 reaction with mechanism - SN2 reaction with mechanism C. Elimination reactions. - E1 reaction with mechanism - E2 reaction with mechanism	9

References:

- Advanced Inorganic Chemistry – J. D. Lee
- Vogels Textbook of Practical organic chemistry.
- Spectroscopy - Kalsi
- A textbook of Physical Chemistry - Glasston Samuel, Macmillan India Ltd. (1991)
- Organic Chemistry - I L Finar volume I and II.

Course Code	Course/Subject Name	Credits
CHC303	Fluid Flow	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 understand basic principles and equations of fluid flow.
- 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. for incompressible and compressible fluids.
- They can select pumps and valves and would be able to calculate power requirement for pumping as well as agitation operations.

Module .No.	Contents	No. of Hours
1	**Introduction and Basic Concepts:** • Scope and Applications of fluid flow • Properties of fluids such as Density, viscosity, surface tension, capillarity effect, vapor pressure, compressibility factor, Enthalpy, Entropy.	2
2	**Pressure and Fluid Statics:** • Fluid Pressure at a Point, • Pascal's Law, • Pressure Variation in a fluid at rest. • Measurement of Pressure • Manometer. • Peizometer U-Table Manometer • Single Column manometer • U – Tube differential manometer • Inverted Differential U – tube manometer • Inclined manometer. • Hydrostatic Equilibrium	4
3	**Fluid Kinematics:** • Types of fluid flow namely steady and unsteady, Uniform and non-uniform, laminar and turbulent, compressible and incompressible,	2

	internal and external, one, two and three dimensional flow. • Concepts of Stream lines, stream tubes. Newton Law of Viscosity, Rheological behavior of fluid	
4	**Basic Equations of Fluid Flow** • Equation of Continuity, • Equation of motion: Euler's equation of motion, Bernoulli's equation from Euler's Equation. • Modified Bernoulli's equation.	**5**
5	**Practical Application of Bernoulli's Equation:** • Venturimeter: Horizontal and inclined. • Orificemeter, Pitot tube • Notches and Weirs: Introduction, classification, Derivation for V – notch.	**5**
6	**Flow through Circular Pipes:** • Shear – Stress, Distribution and velocity distribution for incompressible fluids in cylindrical tube • Relationship between Skin friction and wall shear, friction factor, Darcy's Weisbach equation • Reynolds experiment and Reynolds no., Formation of Boundary layer. **Laminar Flow through Pipes:** • 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.**Von Carman** equation and friction factors (No Numericals on universal velocity) • Equivalent diameter for circular and non circular ducts. • Pipes in series and Parallel. • Losses due to different fittings, sudden expansion etc.	**9**
7	**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. **Flow past immersed bodies:** • Drag forces, Coefficient of drag, Terminal settling velocity, Stoke's Law. Capillary viscometer. **Power Consumption in Agitation:** • Power curves, Power No., types of impellers.	**6**
8	**Pumps and Valves:** • Classification and types, Centrifugal pumps, Introduction, main parts, Work done, Power required, Definitions of heads and efficiency, NPSH, Priming, Cavitations characteristic curves. • Specific speed, minimum speed. **Reciprocating Pump :** • Classifications and working **General idea about Compressors, Fans and Blowers**. **Types of Valves** • Globe valves, Check valves, Gate valves, butterfly valves and non – return valves.	**6**

References:

- Warren L. Mccabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition.
- Coulson J. M., Richardson J. F., Backhurst J. R. and J. H. Harker, Chemical Engineering, Vol. 1
- Fluid Mechanics and Hydraulics by Suresh Ukarande , Ane Books, 2012.
- Introduction to Fluid Mechanics, 7th edition, Robbert W. Fox, Philip J. Pritchard, Alan T. McDonald, WILEY, India Edition.
- Fluid Mechanics Fundamentals and Applications, Yunus A. Cengel, John M. Cimbala, Adapted by S. Bhattacharya, The McGraw Hill Companies.
- Fluid Mechanics and Hydraulic Machines, Dr. R. K. Bansal, Laxmi Publications Pvt. Ltd.

Course Code	Course/Subject Name	Credits
CHC304	Computer Programming and Numerical Methods	4

Prerequisites:

- Differential Calculus.
- Integral Calculus.
- Differential Equations.
- Linear Algebraic Equations.

Course Objectives:

- To familiarize students with the use of software in solving numerical problems.
- To develop analytical thinking in designing programs.
- To learn to interpret results of computer programs and debug the same.
- To learn to present results in graphical form.

Course Outcomes:

- The students will be able to solve linear algebraic equations.
- The students will be able to solve non-linear algebraic equations.
- The students will be able to solve differential equations.
- The students will be able to solve partial differential equations.
- The students will be able make plots of their results.

Module	Contents	No. of hrs
1	• Introduction to Scilab. • Handling vectors and matrices in Scilab. • Program control using For , While and Do loops. • Decision making with If and Case structures.	05
2	• Solution of algebraic and transcendental equations. • RegulaFalsi Method. • Successive substitution. • Secant Method. • Newtons Method one and two simultaneous equations.	9
3	• Systems of linear equations. • Gauss-Seidel Method. • Gauss-Jordan Method.	05
4	• Ordinary differential equations. • Eulers explicit and implicit methods. • Runge-Kutta second and fourth order methods. • Adams-Bashforth formulas.	9
5	• Partial differential equations. • Method of lines. • Crank-Nicholson method. • Laplace equation. • Iterative methods. • Parabolic equations. Bender-Schmidt method.	9
6	• Difference Equations	02

References:

- Programming in ScilabByVinu V Das, New Age International Publishers
- Numerical Methods, M. K. Jain, S. R. K. Iyengar, and R. K. Jain Sixth Edition.New Age International Publishers, New Delhi, 2012.
- Numerical Methods for Engineers. By Santosh K. GuptaNew Age Publishers, Second Edition, 2010
- Introduction to Chemical Engineering Computing by Bruce A. FinlaysonWiley-International, 2005.

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	No. of hrs
1	• Introduction • Units And Dimensions Various systems of units, conversion of units from one system to other • Basic Chemical Calculations, Density, specific volume, specific gravity, Concentration & composition of mixtures and solutions. Density of gases & vapors using Ideal Gas law & Van der waals equation of state, Dalton's law, Amagat,s law, concept of VLE, Raoult's law, Henry's law.	6
2	• Material Balance (For Unit Operations) • 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.	8
3	• Material Balance (for process involving Chemical Reaction)	9
4	• Recycle , Bypass and Purge Calculations (For Module 2 & 3)	3
5	• Calculations using Psychrometric chart; Humidity and saturation	3
6	• Energy Balance • Heat capacity, sensible heat, latent heat, calculation of enthalpy	10

	changes. • General energy balance equation; Energy balances for process involving chemical reaction including adiabatic reactions & combustion processes (Orsat Analysis & Net, Gross Calorific Value determination). Material and Energy Balance (Binary Distillation &Combustion)	

References:

- Stoichiometry- Bhatt , B. I. U., Vora S. M.: Tata McGraw Hill.
- Basic Principles & Calculations in Chemical Engineering- D. M. Himmelblau, Prentice Hall of India Pvt. Ltd.
- R. M. Felder, R. W. Rousseau, Elementary Principles of Chemical Processes; Jonn Wiley Sons, Inc, New York, 1978.

Course Code	Course/Subject Name	Credits
CHC306	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 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.

Module	Contents	No. of hrs
1	**Introduction to Basic Principles of Economics:** • Economics-various definitions • Concept of Need – hierarchy • Market - Concept of Price determination under particular market conditions – perfect competition market & monopoly market, causes • Price Discrimination-concept, types • Concept of Cost-total cost, fixed and variable cost, direct and indirect cost • Cost index – definition, types	**02**
2	**Demand and Supply analysis**: • Law of demand-assumptions and exceptions • Demand schedule and demand curve • Determinants of demand • Changes and variations in demand • Demand elasticity-definition, types, methods of measurement of elasticity, Income elasticity of demand, types. • Law of Supply-assumptions and exceptions • Supply schedule and supply curve • Determinants of supply, changes and variations in supply • Supply elasticity-definition, types, determinants • Methods of measurement of supply	**02**
3	**Economics of production and Growth:** • Production function-types of production economies • Diseconomies of scale • Features of growth • Growth v/s Development • Determinants of growth (economic and non-economic) • Stages of growth • Growth strategy- steady state and big – push growth strategy; balanced and unbalanced growth	**02**
4	**Cost Accounting:** • Outline of Accounting Procedure • Basic Relationship in Accounting • Balance Sheet- types of Asset; Current and Cash Ratio • Income Statement; Debits and Credits; General format of Journal and Ledger • Methods of cost accounting • Accumulation, inventory and cost-of-sales account • Material cost – Different Methods: current average, fifo, lifo	**03**
5	**Interests and Investment Costs:** • Importance of time value of money- Interest and Interest rate; • Types of Interest – Simple interest (ordinary and exact), Compound interest, Nominal and Effective interest rates, Continuous interest • Present worth and Discount • Annuities, Perpetuities and Capitalized costs • Cash Flow in Chemical Projects	**06**

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

References:

- Peters, M. S. and Timmerhaus, K. D. , "Plant design and economics for chemical engineers", latest edition, Mcgraw Hill, New York
- Pravin Kumar "Fundamentals of Engineering Economics" Wiley India.
- Kharbanda, O. P. and Stallworthy, E. A. "Capital cost estimating for process industries", Butterworths, Londen
- K. K Dewett and Adarshchand, " Modern Economic Theory", latest edition, S Chand and Company
- O. P Khanna, "Industrial Engineering and Management" DhanpatRai Publications (P) Ltd.
- AtulSathe, ShubhadaKanchan, "Chemical Engineering Economics", VipulPrakashan, Mumbai

Course Code	Course/Subject Name	Credits
CHL307	Chemical Engineering Lab (FF)	1.5

List of Experiments Suggested:

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

Course Code	Course/Subject Name	Credits
CHL308	Engineering Chemistry-I Lab	1.5

List of Experiments Suggested:

Volumetric analysis:

Preparation of standard solutions and to find normality and deviation factor. [Any 3]

Titrimetric analysis:

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

Organic estimations

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

Gravimetric estimation of

- Barium as $BaCl_2$
- Tin as $SnCl_2$
- Nickel as Ni D.M.G.
- Zinc as $ZnSO_4$

Course Code	Course/Subject Name	Credits
CHL309	Computer Programming and Numerical Methods Lab	1

List of Experiments Suggested:

- Solving a single NLE by Successive Substitution.
- Solving a single NLE by Regula-Falsi method.
- Solving a single NLE by Newton's method.
- Solving a system of linear equations by Gauss Jordan method.
- Solving a system of linear equations by Gauss Seidel method.
- Solving an ODE by Euler's methods.
- Solving an ODE by RK methods.
- Solving an ODE by Adam-Bashforth method.
- Solving a PDE by Crank-Nicholson method.
- Solving a PDE by Bender-Schmidt method.