MVJ College of Engineering, Bengaluru
(An Autonomous Institute)
Affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Recognised by UGC with 2(f) & 12 (B), Accredited by NBA & NAAC
Department of Chemical Engineering

About Department

The Department of Chemical Engineering is committed to providing quality professional education to aspiring engineers. The mission of the department is to facilitate young engineers to acquire technical exposure in the areas of Chemical Engineering, nurture career improvement and develop human and social intellectual qualities necessary for the successful practice of the profession. The department has an annual intake of 60students. The department has well experienced and dedicated faculty members and aims to impart sound knowledge and awareness in the latest trends in the field of Chemical Engineering. The department conducts seminars, guest lectures, paper presentations and industrial visits to bridge the gap between industry and academia.

Department of Chemical Engineering has nine equipped state of the art laboratories to provide the students with the necessary and sufficient backing of practical knowledge. Computer Applications & Simulation lab have 20 computers, which serves to the computing needs of the various programs of the department as well as service courses. The laboratories are also equipped with the software like Aspen Hysys, DWSIM. Chemical Engineering department has created additional facilities and provisions are made to upgrade facilities on continual basis to address current and emerging needs

Vision:

Be a leading Chemical Engineering Department for quality technical education.

Mission:

1. **Quality Teaching: -** Provide high quality education in chemical and allied fields through outcome-based teaching –learning process.
2. **Core competence: -** Empower students and faculties to achieve proficiency in chemical sciences and engineering using state-of-the-art laboratory facilities with modern technologies.
3. **Centre of Excellence:** Stimulate and encourage the pursuit of excellence in Chemical Science and Engineering.
4. **Skill Development:** -Foster graduates with leadership qualities, entrepreneurship skills, innovative thinking and professional ethics.

Programme Educational Objectives

PEO1: Fundamentals: Graduates will apply chemical engineering principles in engineering practice for employability in Chemical and allied industries.

PEO2: Higher Studies &Research: Graduates will pursue their post-graduation and research in the fields of Chemical Engineering, Petrochemicals, Material Science, Biotechnology, Nanotechnology, Environmental Engineering and allied areas.

PEO3: Entrepreneurship: Graduates will apply fundamental knowledge in chemical engineering to nurture technologies for the benefit of humankind and to become successful entrepreneurs.

Programme Specific objectives

PSO1: In-depth knowledge: Acquire in-depth knowledge of process calculations, transport operations, reaction engineering, process control, economics, safety and environmental aspects required to work in the diverse fields such as Petroleum refining, nano technology, food, pharma, energy, environmental engineering etc.
PSO2: Computed aided Design: Solve Chemical engineering problems using computational and simulation tools for design and optimization of chemical processes.

Programme outcomes

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

III Semester, B.E. in Chemical Engineering
[As Per Choice Based Credit System (CBCS)]
Effective from the Academic Year 2020-21

Course Title	Fourier Series, Transforms, Numerical and Optimization Techniques	Semester	III
Course Code	MVJ19MCH31	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 20:10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3hrs

Course objective is to:

- Comprehend and use of analytical and numerical methods in different engineering fields
- Apprehend and apply Fourier Series
- Realize and use of Fourier transforms and Z-Transforms
- Use of statistical methods in curve fitting applications
- Use of numerical methods to solve algebraic and transcendental equations, vector integration and calculus of variation.

Module-1	**RBT Level;** L1, L2 & L3	12 Hrs.

Laplace Transforms: Definition and Laplace transforms of Elementary functions. Laplace transforms of $e^{at}f(t), t^n f(t)$ and f(t)/t, periodic functions and unit step function – problems.

Inverse Laplace Transforms: Inverse Laplace Transforms – Problems, Convolution theorem to find the inverse Laplace transforms and problems, solution of linear differential equations using Laplace Transforms.

Applications:

The Laplace transform is particularly useful in solving linear ordinary differential equations.

Video link / Additional online information:

https://www.youtube.com/watch?v=HSGgORdJAQg
https://www.youtube.com/watch?v=Pq-tUQzeSRw

Module-2	**RBT Level;** L1, L2 & L3	12 Hrs.

Fourier Series: Periodic functions, Dirichlet's condition, Fourier Series of periodic functions with period 2π and with arbitrary period $2c$. Fourier series of even and odd functions. Half range Fourier Series, Practical harmonic Analysis.

Applications:

The Fourier series has many such applications in harmonic analysis, vibration analysis, acoustics, optics etc.

Video link / Additional online information :

https://www.youtube.com/watch?v=4N-IwHUCFa0
https://www.youtube.com/watch?v=UGuOVeoo3QE
https://www.youtube.com/watch?v=x04dnqg-iPw
https://nptel.ac.in/courses/111106111/

http://esg.mit.edu/videos/fourier-series-modeling-nature/
https://www.khanacademy.org/science/electrical-engineering/ee-signals/ee-fourier-series/v/ee-fourier-series-intro

Module-3	**RBT Level;** L1, L2 & L3	12 Hrs.

Fourier transforms:
Infinite Fourier transform, Infinite Fourier sine and cosine transforms, Inverse Fourier transforms, Inverse Fourier sine and cosine transforms, Convolution theorem and problems.

Applications:
Fourier Transformation (FT) has huge application in studying to study vibrations in building/structures. Any kind of spectroscopy applied in chemical engineering (CE) is based in Fourier techniques.
Video link / Additional online information**:**
https://www.youtube.com/watch?v=spUNpyF58BY
https://www.youtube.com/watch?v=6spPyJH6dkQ
https://www.youtube.com/watch?v=WcNPUXfxCXA

Module-4	**RBT Level;** L1, L2 & L3	12 Hrs.

Numerical Methods: Numerical solution of ordinary differential equations of first order and first degree, Taylor's series method,
modified Euler's method. Runge - Kutta method of fourth order, Milne's and Adams-Bash forth predictor and corrector methods (No derivations of formulae-single step computation only.

Applications:
Numerical Methods are used to provide 'approximate' results for the differential equation problems being dealt with and their necessity is felt when it becomes impossible or extremely difficult to solve a given problem analytically.
Video link / Additional online information:
https://www.youtube.com/watch?v=QugqSa3Gl-w

Module-5	**RBT Level;** L1, L2 & L3	12 Hrs.

Numerical Methods: Numerical solution of second order ordinary differential equations, Runge-Kutta method and Milne's method. (No derivations of formulae-single step computation only).
Optimization Techniques:
Linear Programming, Mathematical formulation of linear programming problem (LPP), Types of solutions, Graphical Method, Simplex Method.

Applications:
Linear Programming is used in a variety of fields including food and agriculture, engineering, transportation problems, manufacturing and energy.
Video link / Additional online information:
https://www.youtube.com/watch?v=v63aU0TVFkw

Course outcomes:	
CO1	Communications, Know the use of periodic signals and Fourier series to analyse circuits and system
CO2	Explain the general linear system theory for continuous-time signals and digital signal processing using the Fourier Transform and z-transform
CO3	Solve first and second order ordinary differential equation arising in flow problems using single step numerical methods
CO4	Solve Optimization Technique Problems
CO5	Solving Numerical 2nd order ordinary differential equations

Reference Books:	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2.	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10th edition,2014.
3	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
4	Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition
5	Jain R. K. & Iyengar S.R.K., Advanced Engineering Mathematics, Narosa Publishing House, 2002.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	0	3	0	0	0	0	0	0	0	1
CO2	3	3	0	3	0	0	0	0	0	0	0	0
CO3	2	3	0	3	0	0	0	0	0	0	0	1
CO4	3	3	0	3	0	0	0	0	0	0	0	0
CO5	3	3	0	2	0	0	0	0	0	0	0	1

High-3, Medium-2, Low-1

Course Title	Chemical Process Calculations	Semester	III
Course Code	MVJ19CH32	CIE	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10 : 10	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	4	Exam. Duration	3 hrs

Course objective is to:

- Learn basic laws about the behavior of gases, liquids and solids.
- Apply material and energy balances concepts to formulate and solve problems related to chemical engineering process.

Module-1	**RBT Levels;** L-1, L-2, L3	**12 Hrs.**

UNITS AND DIMENSIONS:
Fundamental and derived units, Conversion, Dimensional consistency of equations, Dimensionless groups and constants, conversions of equations.

BASIC CHEMICAL CALCULATIONS:
Concept of mole, composition of mixtures of solids, liquids and gases - percentage by weight, mole and volume, Ideal gas law calculations. Composition of mixtures and solutions - Normality, Molarity, Molality and ppm. Concentration scales based on specific gravity.

Laboratory Sessions/ Experimental learning:
Preparation of solutions in the lab to understand the concept of composition of mixtures.
Applications: Basics of chemistry of solid, liquid and gases can be applied to any engineering or basic science application which require knowledge of mixtures, unit conversion etc
Video link / Additional online information:
https://nptel.ac.in/courses/103103165/
https://youtu.be/AFm87ncbcRE
https://guides.lib.purdue.edu/c.php?g=352816&p=2377943

Module-2	**RBT Levels;** L-1, L-2, L3	**12 Hrs.**

Vapor Pressure: Definition of vapor pressure, partial pressure, Psychrometry. Material Balance Without Reaction: General material balance equation for steady and unsteady state, Typical steady state material balances on mixing, distillation, extraction, crystallization, Drying & related Problems.

Laboratory Sessions/ Experimental learning:
1. Demonstrate the concept of distillation, extraction and Drying by conducting simple experiments in mass transfer lab.
Applications: Psychometry knowledge will help to understand refrigeration concept related to mechanical engineering. The material balance of unit operation will help in the design and simulation of those processes.
Video link / Additional online information:
https://nptel.ac.in/courses/103103165/
https://youtu.be/SUys-sqi0rQ
https://www.youtube.com/watch?v=XtfBYZuA7rI

Module-3	RBT Levels; L-1, L-2, L3	12 Hrs.

Typical steady state material balances on evaporation, absorption and leaching and problems.
Steady State Material Balance with Reaction: Principles of stoichiometry, Concept of limiting and excess reactants and inert, fractional and percentage conversion, fractional yield and percentage yield, Selectivity, related problems.
Laboratory Sessions/ Experimental learning:

1. Demonstrate the concept of adsorption and leaching by conducting simple experiments in mass transfer lab.
2. Show the working of Single effect evaporator in the Heat transfer lab.

Applications: The material balance of unit operation and processes will help in the design and simulation of those processes. It enables them to understand the raw materials required, yield etc of a given process.
Video link / Additional online information:
https://nptel.ac.in/courses/103103165/
https://youtu.be/p72wC36W83Q
https://nptel.ac.in/courses/102106069/

Module-4	RBT Levels; L-1, L-2, L3	12 Hrs.

Fuels and Combustion: Ultimate and Proximate analysis of fuels, Material balances on combustion processes: Material balances based on combustion reactions, Solving problems. Material balances with and without reactions involving bypass, recycle and purging.
Laboratory Sessions/ Experimental learning:

1. Experiment with reactions in simple reactor to understand the concept of limiting reactant, conversion & Excess reactant.

Applications: Fuel characteristics and its effectiveness in heating purposes can be applied various mechanical as well as chemical fields
Video link / Additional online information:
https://nptel.ac.in/courses/103103165/
https://youtu.be/N9du6edNgqc
https://youtu.be/WhypzrXOVXQ
https://nptel.ac.in/courses/102106069/

Module-5	RBT Levels; L-1, L-2, L3	12 Hrs.

ENERGY BALANCE:
Thermo physics: Energy, energy balances, heat capacity of gases, liquid and mixture solutions. Kopp's rule, latent heats, heat of fusion and heat of vaporization, Trouton's rule, latent heat of vaporization using Clausius - Clapeyron equation. Thermo chemistry: Calculation and applications of heat of reaction, combustion, formation, Kirchhoff's equation, Effect of temperature on heat of reaction. Adiabatic and non-adiabatic reactions. Theoretical and actual flame temperatures**.**
Laboratory Sessions/ Experimental learning:

1. Demonstrate working of bomb calorimeter to understand the fuel heat capacity measurement

Applications: Energy balance concept can be applied in any energy required processes and is basic step in chemical process design.
Video link / Additional online information:
https://nptel.ac.in/courses/103103165/
https://youtu.be/0H0OpEsG8ak
https://nptel.ac.in/courses/102106069/

Course Outcome:	
CO1	Comprehend the basic theories in stoichiometry and perform unit conversions and calculations.
CO2	Solve material balance problems of steady state unit operations like drying, mixing, evaporation, distillation, humidification etc.
CO3	Apply material balance concept to solve multistage operations like bypass, recycle and purging
CO4	Apply the concept of material balance for process with reactions.
CO5	Explain the concepts of thermo physics and thermo chemistry and solve steady state enthalpy balance problems.

Reference Books**:**	
1.	**B.I Bhatt and S.M Vora "***Stoichiometry (SI Units)"***"**, 3rd edn, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
2.	Hougen O.A., Watson K.M. and Ragatz R.A., **"Chemical Process Principles-Part I" "Material and Energy balances"**, 2nd Edn, CBS publishers and distributors, New Delhi, 1995.
3	Himmelblau D.M., "Basic principle and Calculations in Chemical Engineering", 6thedn, Prentice Hall of India, New Delhi,1997
4	Richard M. Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, John Wiley & Sons, 3rd Edition, 2005.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	0	0	0	0	0	0	0	0	1
CO2	3	3	3	0	0	0	0	0	0	0	0	0
CO3	3	3	3	0	0	0	0	0	0	0	0	0
CO4	3	3	3	0	0	0	0	0	0	0	0	0
CO5	3	3	3	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	Momentum Transfer	Semester	III
Course Code	MVJ19CH33	CIE	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10 : 10	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	3	Exam. Duration	3 hrs

Course objective is to:

- Understand concepts on nature of fluids, type of fluid flow and boundary layer relations, pressure concepts and its measurement by various experimental methods and enhancement of problem-solving skills.
- Understand relationship between kinetic energy, potential energy, internal energy and work complex flow systems using Bernoulli's equation with application to industrial problems.
- Understand clear concepts on Flow of compressible and incompressible fluids in conduits and thin layers and friction factor variations with velocity and friction losses using Bernoulli's Equations and they will be demonstrated experimentally.
- Study Dimensional analysis and working of pumps, transportation and metering of fluids using various techniques and applications to industry.

Module-1	**RBT Levels;** L-1, L-2, L3	12 Hrs**.**

FLUID STATICS AND ITS APPLICATIONS:

Concept of unit operations, Concept of momentum transfer, Nature of fluids and pressure concept, variation of pressure with height – hydrostatic equilibrium, Barometric equation, Measurement of fluid pressure – manometers, Continuous gravity decanter, Centrifugal decanter**.**

FLUID FLOW PHENOMENA:

Type of fluids – shear stress and velocity gradient relation, Newtonian and Non- Newtonian fluids, Viscosity of gases and liquids. Types of flow – laminar and turbulent flow, Reynolds stress, Eddy viscosity. Flow in boundary layers, Reynolds number, and Boundary layer separation and wake formation.

Laboratory Sessions/ Experimental learning: Venturi and Orifice meter, study correlation between Reynolds number and friction factor

Applications: Students can understand the measurement of pressure using devices like manometers, and also the flow behaviour by analyzing Reynolds number.

Video link / Additional online information :

http://vlabs.iitb.ac.in/vlab/chemical/exp1/index.html

Module-2	**RBT Levels;** L-1, L-2, L3	12 Hrs**.**

BASIC EQUATIONS OF FLUID FLOW: Average velocity, Mass velocity, Continuity equation, Euler and Bernoulli equations Modified equations for real fluids with correction factors, Pump work in Bernoulli equation, Angular momentum equation.

FLOW OF INCOMPRESSIBLE FLUIDS IN CONDUITS AND THIN LAYERS:

Laminar flow through circular and non-circular conduits, Hagen Poiseuille equation, Laminar flow of Non-Newtonian liquids, Turbulent flow in pipes and closed channels.

Laboratory Sessions/ Experimental learning: Experimentation to verify the generalized correlation

between Reynolds number and friction factor in Annulus, circular and non-circular pipes.
Applications: To analyse the flow patterns of incompressible fluids in various conduits.
Video link / Additional online information:
http://uorepc-nitk.vlabs.ac.in/exp1/index.html

Module-3	**RBT Levels;** L-1, L-2, L3	12 Hrs.

FLOW OF INCOMPRESSIBLE FLUIDS IN CONDUITS AND THIN LAYERS: (Contd...)
Friction factor chart, friction from changes in velocity or direction, Form friction losses in Bernoulli equation, Flow of fluids in thin layers

FLOW OF COMPRESSIBLE FLUIDS:
Continuity equation, Concept of Mach number, Total energy balance, Velocity of sound, Ideal gas equations, Flow through variable-area conduits, Adiabatic frictional flow, Isothermal frictional flow (elementary treatment only).
Laboratory Sessions/ Experimental learning: Study of finding co efficient of losses in straight pipes due to sudden enlargement, sudden contraction and bends.
Applications: Frictional losses due to change in area and direction of pipes in various pipes and conduits can be studied. Frictional losses due to change in area and direction of pipes in various pipes and conduits can be studied.
Video link / Additional online information:
https://www.youtube.com/watch?v=mflbEZ7kUpU

Module-4	**RBT Levels;** L-1, L-2, L3	12 Hrs.

TRANSPORTATION AND METERING OF FLUIDS: Pipes, Fittings and valves, Flow measuring devices, venturi meter, orifice meter, rotameter and pitot tube. Elementary concept of target meter, vortex-shedding meters, turbine meters, positive displacement meters, magnetic meters, Coriolis meters and thermal meters, Flow through open channel-weirs and notches.

Performance and Characteristics of pumps-positive displacement and centrifugal pumps, Fans, compressors, and blowers.

Laboratory Sessions/ Experimental learning: Determination of co efficient of discharge of Venturi meter, orifice meter and notches experimentally and graphically. Also working of single and multi-stage centrifugal pump.
Applications: Students will be able to analyze the variations in discharge in various meters and notches like rectangular and v notch. also characteristics of centrifugal pump.
Video link / Additional online information:
https://uta.pressbooks.pub/appliedfluidmechanics/chapter/experiment-10/

Module-5	**RBT Levels;** L-1, L-2, L3	12 Hrs.

FLOW OF FLUID PAST IMMERSED BODIES:

Drag, drag coefficient, Pressure drop – Kozeny-Carman equation, Blake-Plummer, Ergun equation, Fluidization, conditions for fluidization, Minimum fluidization velocity, Pneumatic conveying, Industrial application of Fluidization.

DIMENSIONAL ANALYSIS:

Dimensional homogeneity, Rayleigh's and Buckingham Π- methods, Significance of different dimensionless numbers.

Laboratory Sessions/ Experimental learning: Demonstration of flow past packed and Fluidized bed.
Applications: Dimensional analysis help to find the relationship among various variable in any chemical, mechanical systems. Most chemical engineering system require flow of fluid pat solid

catalyst adsorbent absorbent etc .This learning will help to analyze flow of fluid over such systems. Video link / Additional online information: https://www.youtube.com/watch?v=OdldY3RLw24

Course Outcomes:	
CO1	Apply the concepts of fluid statics and dynamics to measure pressure and differentiate various flow phenomena.
CO2	Derive the fundamental equations and apply to solve various fluid flow problems
CO3	Understand the various equations for incompressible and compressible fluids in conduits.
CO4	Demonstrate the knowledge of fluid flow principles in various types of flow measurements, transportation and metering of fluids using experimental techniques and applications to industry.
CO5	Develop functional relationships using dimensional analysis and similitude to solve technical problems also to analyze the flow past immersed bodies.

Reference Books:	
1.	B McCabe, W.L., et.al, "Unit Operations in Chemical Engineering", 5th edn., McGraw Hill, New York 1993.
2.	Kumar K.L., "Engineering Fluid Mechanics", Eurasia Publishing House (p) Ltd., New Delhi, 3rdedn. 1984.
3	Dr R K Bansal., "A Text Book of Fluid Mechanics" 1stedn., Laxmi Publications (P) Ltd., New Delhi. 2005.
4	Coulson J.H. and Richardson J.F., "Chemical Engineering", Vol-I, 5thedn., Asian Books (p) Ltd., New Delhi, 1998
5	Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill, New York, 1997.
6	Web Link and Video Lectures: https://nptel.ac.in/courses/103104043/ https://cosmolearning.org/courses/fluid-mechanics-chemical-engineering/video-lectures/

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	0	0	0	0	0	0	0	0	0
CO2	3	3	3	0	0	0	0	0	0	0	0	0
CO3	3	3	3	0	0	0	0	0	0	0	0	0
CO4	3	3	3	0	0	0	0	0	0	0	0	1
CO5	3	3	3	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	Mechanical Operations	Semester	III
Course Code	MVJ19CH34	CIE	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10 : 10	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	3	Exam. Duration	3 hrs

Course objective is to:

- Study different properties of particulate solids, handling and mixing of solid particles.
- Study principles of comminution and different types of equipment for size reduction like crushers, grinders etc.
- Understand mechanical separation aspect such as screening, filtration, sedimentation, transportation of solids etc.
- Understand energy requirements in solids handling, agitation and mixing, solid conveying and storage

Module-1	**RBT Levels;** L-1, L-2, L3	12 Hrs.

PARTICLE TECHNOLOGY:

Particle shape, particle size, Different ways of expression of particle size, Shape factor, sphericity, Particle size analysis, Screens – ideal and actual screens, Tyler series, Differential and Cumulative size analysis, Effectiveness of screen, Specific surface of a mixture of particles, Number of particles in a mixture, Standard screens, Motion of screen, Industrial screening equipment: Grizzly, Gyratory screen, Vibrating screen, Trommels, Sub sieve analysis – Air permeability test, Air elutriation, Beaker decantation.

Laboratory Sessions/ Experimental learning:
Differential and cumulative size analysis method to measure the size distribution of products obtained from vibrating screen, To find out the effectiveness of screen.
Applications:
Students can understand the measurement method of size distribution of different sized particles.
Video link / Additional online information:
https://www.russellfinex.in/vibrating-screen/?param1=%2Bvibrating%20%2Bscreen&gclid=EAIaIQobChMInZLMp5_-6AIV0sEWBR3eMAqREAAYASAAEgJgP_D_BwE

Module-2	**RBT Levels;** L-1, L-2, L3	12 Hrs.

SIZE REDUCTION:

Introduction – types of forces used for comminution, Criteria for comminution, Characteristics of comminute products, Laws of size reduction, Work Index, Energy utilization, Methods of operating crushers – Free crushing, Choke feeding, Open circuit grinding, Closed circuit grinding, Wet and Dry grinding, Equipment for size reduction – Classification of size reduction equipment, Equipment – Blake jaw crusher, Gyratory crusher, Smooth roll crusher, Toothed roll crusher, Impactor, Ball mill, Critical speed of ball mill, Cutters – Knife cutter, Ultrafine grinder-Fluid energy mill, Colloid mill.

Synthesis of nano-particle - Top-down methods

Laboratory Sessions/ Experimental learning:
To determine the energy required for crushing the given feed and thus obtain the work index for the same. Also determine the reduction ration and critical speed of the mill and to determine the crushing law constants and verify the laws using jaw crusher.
Applications: Ball mill and crushers are used in various industries like cement industry, mineral industry and ceramic industry for reducing the size of particles
Video link / Additional online information:

https://www.youtube.com/watch?v=TlVxZlGiKyc
https://www.youtube.com/watch?v=1CpjRMICXNM
https://www.youtube.com/watch?time_continue=32&v=kOy0yuWpUzU&feature=emb_title

Module-3	**RBT Levels;** L-1, L-2, L3	12 Hrs.

FILTRATION:

Introduction, Classification of filtration, Cake filtration, Clarification, batch and continuous filtration, Pressure and vacuum filtration, Derivation of Constant rate filtration and Constant Pressure filtration, Characteristics of filter media, Industrial filters: Sand filter, Filter press, Leaf filter, Rotary drum filter, Principles of Centrifugal filtration, Rate of washing – Suspended batch centrifuge, Filter aids, Application of filter aids.

Laboratory Sessions/ Experimental learning:
Demonstrate the working of a leaf filter and Plate & Frame filter
Applications: Filtration is used to separate particles and fluid in a suspension, where the fluid can be a liquid, a gas or a supercritical fluid. Filtration is major unit operation in edible oil manufacturing, water treatment etc
Video link / Additional online information:
https://www.youtube.com/watch?v=lRBPQmectLQ
http://uorepc-nitk.vlabs.ac.in/exp6/index.htmlv

Module-4	**RBT Levels;** L-1, L-2, L3	12 Hrs.

MOTION OF PARTICLES THROUGH FLUIDS:

Mechanics of particle motion, Equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, Terminal velocity, Motion of spherical particles in Stokes's region, Newton's region, and Intermediate region, Criterion for settling regime, Hindered settling, Modification of equation for hindered settling.

SEDIMENTATION:

Batch settling test, Coe and Clevenger theory, Kynch theory, thickener design, Equipment: Gravity Settling Tank, Disk Bowl Centrifuge.
Laboratory Sessions/ Experimental learning:
Batch sedimentation test, To determine the specific cake resistance and filter medium resistance, Rm by Filtration method.

Applications: Batch sedimentation test can be conducted to design the sedimentation tank. Both

are useful for the separation of the solid suspended particle from waste water
Video link / Additional online information:

https://www.youtube.com/watch?v=M4wBd1_CvNw

https://www.youtube.com/watch?v=gCJ3b8UM4EQ

Module-5	**RBT Levels;** L-1, L-2, L3	12 Hrs.

AGITATION AND MIXING:

Application of agitation, Agitation equipment, Types of impellers – Propellers, Paddles and Turbines, Flow patterns in agitated vessels, Prevention of swirling, Standard turbine design, Power correlation and power calculation, mixing of solids, mixing index, Types of mixers –, Muller mixers, Mixing index, Ribbon blender, Internal screw mixer.

SAMPLING, STORAGE AND CONVEYING OF SOLIDS:

Sampling of solids, Storage of solids, Open and closed storage, Bulk and bin storage, Conveyors – Belt conveyers, Chain conveyor, Apron conveyor, Bucket conveyor, Screw conveyor. MISCELLANEOUS SEPARATION: Centrifugal separators: Cyclones and Hydro cyclones, Magnetic separation, Electrostatic separation.

Laboratory Sessions/ Experimental learning: To separate the iron filings from the sand particles by performing froth floatation experiment.
Applications: There are various industrial application of separation equipment i,e froth floatation, ESP, heavy media separator, magnetic separator which is discussed in this module.
Video link / Additional online information:
https://www.youtube.com/watch?v=eu4T080dsG8
https://www.youtube.com/watch?v=nlfJt9rXWto

Course Outcomes:	
CO1	Study different properties of particulate solids, handling and mixing of solid particles.
CO2	Study principles of comminution and different types of equipment for size reduction like crushers, grinders etc.
CO3	Derive the expression to find rate of filtration for various types of filtration and to study the working of various filtration equipment's.
CO4	Explain the phenomenon of motion of particles through fluids in various flow fields and regimes, Outline the various theories of Sedimentation in designing industrial thickeners.
CO5	Explain various miscellaneous separation processes and also illustrates the working principle of agitation and mixing and describe the sampling of solid and conveying of it.

Reference Books:	
1.	McCabe, W.L., et.al., "Unit Operations in Chemical Engineering", 5thedn., McGraw Hill International, Singapore, 2000
2.	Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", 3rdedn. Tata McGraw Hill International Edition, Singapore, 1999.
3	Coulson J.H. and Richardson J.F., "Coulson and Richardson's Chemical Engineering", Vol-II Particle Technology and Separation Process, 6thedn., Asian Books (p) Ltd., New Delhi, 1998
4	Brown G.G., et.al., "Unit Operations", 1st edn., CBS Publisher, New Delhi, 1995
5	Foust A.S., et.al., "Principles of Unit Operations", 3rd edn., John Wiley and Sons, New York, 1997
6	**Web Link and Video Lectures:** **1.** https://nptel.ac.in/courses/103107123/ **2.** https://swayam.gov.in/nd1_noc19_ch32/preview

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	0	0	0	0	0	0	0	0	0
CO2	3	3	2	0	0	0	0	0	0	0	0	0
CO3	3	3	2	0	0	0	0	0	0	0	0	0
CO4	3	3	3	0	0	0	0	0	0	0	0	0
CO5	3	3	1	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	Materials Science for Chemical Engineers	Semester	IV
Course Code	MVJ19CH35	CIE	50
Total No. of Contact Hours	60 L: T: P:: 40 : 10 : 10	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	3	Exam. Duration	3 hrs

Course objective is to:

- Understand concepts on properties and selection of metals, ceramics, and polymers for design and Manufacturing.
- Study variety of engineering applications through knowledge of atomic structure, electronic structure, chemical bonding, crystal structure, X-rays and X-ray diffraction, defect structure.
- Study Microstructure and structure-property relationships, Phase diagrams, heat treatment of steels.
- Study detailed information on types of corrosion and its prevention.
- Learn information on selection of materials for design and manufacturing.

Module-1	**RBT Level;** L1, L2 & L3	12 Hrs.

Introduction: Engineering Materials – Classification – levels of structure, structure property relationships in materials.

Crystal Geometry and Structure Determination: Geometry of crystals – the Bravais lattices, Crystal directions and planes – the miller indices, Structure determination – X –Ray diffraction-Bragg law, the powder method, Electron diffraction &Neutron diffraction.

Atomic structure and Chemical bonding & Structure of solids: Periodic table, Ionization potential, Electron affinity and Electro-negativity, Correlation between Bonding and the Properties of Solids (Ionic, molecular, covalent, metallic solids)

Laboratory Sessions/ Experimental learning: (1) To find the ionization potential of mercury using a gas-filled diode. (2) To measure the absorbance of the sample at different wavelengths & to find out the unknown concentration of the sample by using spectrophotometer.

Applications: (1) Ionization potential can predict the strength of chemical bond (2) directly used to measure light intensity at different wavelength & used to determine unknown concentration of solution

Video link / Additional online information:

http://apniphysics.com/viva/ionization-experiment-physics/

https://vlab.amrita.edu/?sub=2&brch=190&sim=338&cnt=1

Module-2	**RBT Level;** L1, L2 & L3	12 Hrs.

Crystal Imperfection: Point Imperfections, Line imperfections – edge and screw dislocations, the Burgers vector, line energy of dislocations, Surface imperfections

Basic thermodynamic functions: phase diagrams and phase transformation: Single component systems, Binary phase diagrams, Lever rule, typical phase diagrams for Magnesia-Alumina, Copper – Zinc, iron –

carbon systems, Nucleation and growth. Solidification, Allotropic transformation

Laboratory Sessions/ Experimental learning: Heat treatment processes can be adopted to study the phase transformation
Applications: Phase transformation can be adopted to predict the various crystal structure of metals
Video link / Additional online information:
http://www.cittumkur.org/mech2019/MTLab.pdf

Module-3	**RBT Level;** L1, L2 & L3	12 Hrs.

Deformation of Materials and Fracture: Elastic deformation, Plastic deformation, Visco-elastic deformation, Stress and strain curve for ductile & brittle material, creep, Different types of fracture. Heat Treatment: Annealing, Normalizing Hardening, Martempering, Austempering, Hardenability, Quenching, Tempering, Furnace types.

Laboratory Sessions/ Experimental learning: (1) To determine Young's modulus of elasticity of the material of a given wire. (2) To study the heat treatment process (Annealing)
Applications: (1) Young's modulus of elasticity defines the relationship between stress (force per unit area) and strain (proportional deformation) in a material. (2) Annealing reduces internal stress, softens the metal & improve the ductility of metals
Video link / Additional online information:
https://byjus.com/physics/to-determine-youngs-modulus-of-elasticity-of-the-material-of-a-given-wire/ http://www.cittumkur.org/mech2019/MTLab.pdf

Module-4	**RBT Level;** L1, L2 & L3	12 Hrs.

Corrosion and its Prevention: corrosion and its manifestations, consequences, direct corrosion, Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, factors influencing corrosion rate, control and prevention of corrosion-modification of corrosive environment, inhibitors, protective coatings, Specific types of corrosion.

Laboratory Sessions/ Experimental learning: Construction & working of galvanic cell
Applications: Galvanic cells and batteries are typically used as a source of electrical power.
Video link / Additional online information :
https://www.uccs.edu/Documents/chemistry/nsf/106%20Expt9V-GalvanicCell.pdf

Module-5	**RBT Level;** L1, L2 & L3	12 Hrs.

TYPICAL ENGINEERING MATERIALS: Ferrous metals, non-ferrous metals and alloys, Aluminium and its alloys, Copper and its alloy, Lead and its alloy, Tin, Zinc and its alloy, silicon and its alloys**,** Alloys for high temperature service, Ceramic materials- structure of ceramics, polymorphism, Mechanical, electrical and thermal properties of ceramics phases, Refractories, Glasses, abrasives, plastics, fibres, and elastomers, Organic protective coating.
Laboratory Sessions/ Experimental learning: To determine the shear stress & hardness of engineering materials
Applications: To select the material of construction in automotive, structural, failure analysis, quality control, aerospace & other types of industries
Video link / Additional online information:
http://www.cittumkur.org/mech2019/MTLab.pdf

Course Outcomes:	
CO1	Classify different types of engineering materials depending on structure property, crystal geometry and X-Ray diffraction, atomic structures, types of bonding.
CO2	Explain crystal imperfections and. Draw phase diagrams of different metals, TTT curves.
CO3	Enumerate deformation of materials and Suggest different type of heat treatment techniques depending on the type of the material.
CO4	Interpret different types of corrosions and suggest preventive methods
CO5	Select materials depending on type of application.

Reference Books:	
1.	Raghavan V., "Materials Science and Engineering – A First Course", 3rdedn., Prentice Hall of India Pvt. Ltd., New Delhi, 1996
2.	Hajra Choudhury S.K., "Materials Science and Processes", Indian book distributing Co., 1982
3	Van Vlack H.L., "Elements of Material Science", 2ndedn., Addison – Wesly Publishing Company, New York, 1964.
4	Science of Engineering Materials, vols. 1&2, Manas Chanda, McMillan Company of India Ltd.
5	**Web Link and Video Lectures:** 1. https://nptel.ac.in/courses/113107078/ 2. https://freevideolectures.com/course/2266/material-science

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	0	0	0	0	0	0	0	0	0	0
CO2	2	2	0	0	0	0	0	0	0	0	0	0
CO3	2	2	0	0	0	0	0	0	0	0	0	0
CO4	2	2	0	0	0	0	0	0	0	0	0	0
CO5	2	2	0	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	Technical Chemistry	Semester	III
Course Code	MVJ19CH36	**CIE**	50
Total No. of Contact Hours	60 L: T: P :: 40 : 10 : 10	**SEE**	50
No. of Contact Hours/week	5	**Total**	100
Credits	3	**Exam. Duration**	3hrs

Course objective is to:

- Familiarize the students with the principles of some important topics in physical Chemistry, Inorganic Chemistry and Organic Chemistry.
- Study Dimensional analysis and working of pumps, transportation and metering of fluids using various techniques and applications to industry.

Module-1	**RBT Levels;** L-1, L-2, L3	12 Hrs.

BONDING: Atomic and Molecular orbital theory:
Theory of bonding, Types of bonds, Hydrogen bond with discussion on interaction between two atoms such as exchange of electron, screen effect of electrostatic-bonding, Bond theory of metals, Theory of resonance, Structural stability, structure of carbonate ion and benzene, Importance of resonance compounds.

Laboratory Sessions/ Experimental learning:
Nitration of aromatic compound (Stabilization of carbonium ions)

Applications: This is the basic concepts for developing and synthesizing new chemical compounds for various application.

Video link / Additional online information:
http://www.ch.ic.ac.uk/vchemlib/course/mo_theory/

Module-2	**RBT Levels;** L-1, L-2, L3	12 Hrs.

PHASE RULE: Definition of terms, derivation and application of phase rule consisting of two component system.

SURFACE CHEMISTRY: Introduction, adsorption and absorption, types of adsorption, physical and chemical adsorption, adsorption isotherms, Freundlich, Langmuir and BET and applications of adsorption-industrial, general, analytical.

Laboratory Sessions/ Experimental learning: Preparation of adsorbents for the treatment of coloured waste water.
Applications: Concepts of surface chemistry and phase rule play a vital role in the field of catalysis and metallurgy industries
Video link / Additional online information:

https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112107248/lec9.pdf

Module-3	RBT Levels; L-1, L-2, L3	12 Hrs.

ISOMERISM:

Definition, Types, Conformational isomerism in alkanes, free rotation about carbon- carbon single bond, conformation of ethane, propane n, butane, relative stability of different conformations. Optical isomers – Isomer number & tetrahedral carbon atom chirality, optical isomerism with one asymmetric carbon atom, Polarimeter, Specific rotation, Enantiomerism R & S Nomenclature. Geometrical isomerism – Definition, conditions for geometrical isomerism, cis-trans & E-Z nomenclature, physical & chemical properties of geometrical isomerism.

COORDINATION CHEMISTRY:

Werner's theory, Nomenclature, properties effective atomic number, stability of complex ions, factors affecting the stability, Bonding in coordination compounds, Crystal field theory, stereochemistry of co-ordination compounds. Isomerism of co-ordination compounds. Importance of coordination compounds.

Laboratory Sessions/ Experimental learning: Complexation reactions of different metals with the help of ligand.

Applications: Metal complexes are used in dye industry and pharmaceuticals.

Video link / Additional online information:

https://nptel.ac.in/courses/104105033/

Module-4	RBT Levels; L-1, L-2, L3	12 Hrs.

HETEROCYCLIC COMPOUNDS:

Nomenclature, Classification, Structure, Preparation, Properties & Reactions of Heterocyclic, Analogues of Cyclopropane, Cyclo butane Cyclopentadiene, Heterocycle's one or more hetero atoms, Azetidenes, Furans, Pyratidine, Pyroles, diazines, Fused heterocyclic, Heterocyclics in Dyes, Medicines, Natural products.

Laboratory Sessions/ Experimental learning:

Synthesis of the methyl orange/methyl red by diazo coupling.

Applications: Heterocyclic compounds are the important precursors or intermediates for various industrially important compounds (Dyes, Natural products, Medicines etc.)

Video link / Additional online information:

https://nptel.ac.in/courses/104105034/

Module-5	RBT Levels; L-1, L-2, L3	12 Hrs.

REACTIONS & MECHANISMS:

Concept of Steady states, reactive intermediates, Carbanions, Carbocations, Inductive and resonance effects. Mechanism of nucleophilic substitution (SN1 and SN2) in alkyl halides. Mechanism of elimination reactions (E1 and E2). Mechanism of electrophilic substitution in benzene, nitration, sulphonation, halogenation. Friedel-crafts alkyl and acylation reactions. Electronic interpretation of orienting influence of substituents in aromatic electrophilic of

toluene, chlorobenzene, phenol, Benzonitrile, aniline and nitrobenzene. Solvents effects.

Laboratory Sessions/ Experimental learning:
Bromination reaction of phenols/Aniline/Toluene
Applications: Electrophilic reactions are key steps in petrochemical reactions.
Video link / Additional online information **:**
https://nptel.ac.in/courses/104/101/104101005/

Course outcomes:	
CO1	Explain the bond theory Resonance theory H-O-H Bonds
CO2	Understand the techniques of Surface chemistry and phase rule and their application in industry.
CO3	Explain the structure and bonding of coordination compounds with proper reason of deviation, isomerism prevailing
CO4	Write reaction mechanisms in various types of reactions.

Reference Books:	
1.	Puri L.R. and Sharma B.R., **"Physical Chemistry"**, 14th edn., Chand S. and Company, New Delhi, 1998.
2.	James Huheey, **"Inorganic Chemistry"**, 19thedn. Wiley Publishers, New Delhi, 1997.
3.	Dhone D. B., A Text Book of Plant Utilities, Nirali Publications.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	0	0	0	0	0	0	0	0	0
CO2	3	3	3	0	0	0	0	0	0	0	0	0
CO3	3	3	2	0	0	0	0	0	0	0	0	0
CO4	3	1	3	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	Momentum Transfer Lab	Semester	III
Course Code	MVJ19CHL37	CIE	50
Total No. of Contact Hours	40 L : T : P :: 0: 10 : 30	SEE	50
No. of Contact Hours/week	3	Total	100
Credits	2	Exam. Duration	3 hrs

Course objective is to:

This course aims to familiarize students with the principles of Fluid mechanics.

Laboratory Experiments:	**RBT Levels;** L-1, L-2, L3, L4	40 Hrs**.**

1.	Friction in circular pipes.
2.	Friction in non-circular pipes.
3.	Friction in helical/spiral coils.
4.	Flow measurement using venturi (incompressible fluid).
5.	Flow measurement using orifice meters (incompressible fluid).
6.	Flow over notches- find the coefficient of discharge through various notches.
7.	Flow through open orifice-Hydraulic coefficients.
8.	Flow through Packed bed- Verify ERGUN'S Equation
9.	Flow through Fluidized bed- to calculate the minimum fluidization velocity
10.	Study of characteristics for centrifugal, Positive displacement pump
11.	Study of various pipe fittings and their equivalent lengths.
12.	Unsteady flows - Emptying of Tank

Minimum of 10 experiments are to be conducted

Course Outcome:	
CO1	Identify, name, and characterize flow patterns and regimes.
CO2	Measure fluid pressure and relate it to flow velocity.
CO3	Demonstrate practical understanding of friction losses, coefficient of discharge in various notches and pipes.
CO4	Explain fluid flow in channels and application of flow meters and notches.
CO5	Study of characteristics & efficiency of centrifugal, Positive displacement pump

Reference Books:	
1.	**B** McCabe, W.L., *et.al,* **"Unit *Operations in Chemical Engineering*"**, 5th edn., McGraw Hill, New York 1993.
2.	Kumar K.L., **"*Engineering Fluid Mechanics*"**, Eurasia Publishing House (p) Ltd., New Delhi, 3rdedn. 1984.
3	Dr R K Bansal., "***A Text Book of Fluid Mechanics***" 1stedn., Laxmi Publications (P) Ltd., New Delhi. 2005.
4	Coulson J.H. and Richardson J.F., **"*Chemical Engineering*"**, Vol-I, 5thedn., Asian Books (p) Ltd., New Delhi, 1998
5	Badger W.L. and Banchero J.T., **"*Introduction to Chemical Engineering*"**, Tata McGraw Hill, New York, 1997.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	0	0	0	0	0	0	0	0	0
CO2	3	2	2	0	0	0	0	0	0	0	0	0
CO3	3	2	2	0	0	0	0	0	0	0	0	0
CO4	3	2	2	0	0	0	0	0	0	0	0	0
CO5	3	2	2	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	Technical Chemistry Lab	**Semester**	III
Course Code	MVJ19CHL38	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 0 : 10 : 30	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	2	**Exam. Duration**	3hrs

Course objective is to:

This course aims to familiarize students with the principles of technical chemistry and basic analytical techniques including volumetric analysis.

Laboratory Experiments:	**RBT Levels;** L-1, L-2, L3, L4	40 Hrs**.**
1. Critical Solution Temperature- Water – Phenol System		
2. Estimation of dissolved oxygen in given sample of water by Winkler's method.		
3. Estimation of Iodine & Saponification number of vegetable oil		
4. Analysis of Bleaching Powder -Available chlorine		
5. Heats of mixing -Water –HCl system		
6. Conductometric estimation- Water hardness estimation		
7. Colorimetric Estimation – Potassium dichromate Estimation		
8. Analysis of coal- Moisture Volatile matter & Ash content		
9. Study of kinetics of reaction between $K_2S_2O_8$ and KI		
10. Conductometric determination of equivalent conductance of acetic acid at infinite		
11. Estimation of phenol by iodometric method		
12. Preparation of p-bromo acetanilide from acetanilide		
13. Colorimetric estimation of fluoride in water using SPADNS reagent		

Minimum of 10 experiments are to be performed

Course outcomes:	
CO1	Explain and perform analytics of quantitative estimation by volumetric method of metal and alloys, oil and proximate analysis of coal.
CO2	Determine disinfectant and water quality parameter analysis to assess the quality of water.
CO3	Analyse kinetics, partition co-efficient, transition temperature, percentage composition of binary mixture, critical solution temperature and molecular weight of chemical components.
CO4	Predict the organic reaction mechanism and to estimate functional groups employing different techniques.

CO5	Have knowledge of handling instruments for precise analysis.

Reference Books:	
1.	Essentials Of Experimental Engineering Chemistry By Shashi Chawla, Dhanpat Rai Publications.
2.	Vogel's Quantitative Chemical Analysis By J. Mendham, R.C. Denney, J. D. Barnes, M.J.K. Thomas, Pearson.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	0	1	1	1	1	0	0	0	1
CO2	3	3	3	0	1	1	1	1	0	0	0	1
CO3	3	3	2	0	1	1	3	1	0	0	0	1
CO4	3	3	2	0	1	1	1	1	0	0	0	1
CO5	3	3	2	0	1	1	1	1	0	0	0	1

High-3, Medium-2, Low-1