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.

IV th Semester, B.E. in CHEMICAL ENGINEERING
[As Per Choice Based Credit System (CBCS)]
Effective from the Academic Year 2020-2021

Course Title	Complex Analysis, Probability And Sampling Theory	Semester	IV
Course Code	MVJ19MCH41	CIE	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3hrs

Course objective is to:

The purpose of this course is to make students well conversant with numerical methods to solve ordinary differential equations, complex analysis, sampling theory and joint probability distribution and stochastic processes arising in science and engineering.

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

Complex Variables-I: Review of a function of a complex variable, limits, continuity, and differentiability. Analytic functions-Cauchy-Riemann equations in Cartesian and polar forms. Properties and construction of analytic functions. Complex line integrals-Cauchy's theorem and Cauchy's integral theorem. Conformal transformations-Discussion of transformations: w=z 2 , w=ez, w =z +(1 z)(z ≠ 0).

Applications: It is useful in many branches of mathematics, including algebraic geometry, applied mathematics; including the branches of hydrodynamics, thermodynamics, and particularly quantum mechanics.

Video link / Additional online information :

https://www.youtube.com/watch?v=oiK4gTgncww

https://www.youtube.com/watch?v=WJOf4PfoHow

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

Statistical Methods: Introduction, Correlation and coefficient of co relation, Regression, line of regression problems.

Curve Fitting: Curve fitting by the method of least squares- fitting of the curves of the form, $y = ax + b$, $y = ax^2 + bx + c$ and $y = ae^{bx}$.

Applications: Correlation and Regression is used to see whether two variables are associated, without necessarily inferring a cause-and-effect relationship. Another important application is to estimate the value of one variable corresponding to a particular value of the other variable. Curve Fittings such as parabola and hyperbola are used in architecture to design arches in buildings.

Video link / Additional online information:

https://www.youtube.com/watch?v=xTpHD5WLuoA

https://www.youtube.com/watch?v=fNLeogEjMmM https://www.youtube.com/watch?v=tl5QNhSe0Yk

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

Probability Distributions: Random variables (discrete and continuous), probability mass/density functions. Binomial distribution, Poisson distribution. Exponential and normal distributions, problems.

Applications: Few of the application areas include in industries, quality control, in errors correction, medicine, agriculture, engineering, for analysis and interpretations of basic data obtained from experiments.

Video link / Additional online information :

https://www.youtube.com/watch?v=nrkd0IlVxkY

https://www.youtube.com/watch?v=6x1pL9Yov1k

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

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation, covariance.

Stochastic Process: Probability vector, Stochastic matrices, fixed points, regular stochastic matrices, Markov chains, higher transition probability – problems.

Applications: Sstochastic processes are widely used as mathematical models of systems and phenomena that appear to vary in a random manner.

Video link / Additional online information:
https://www.youtube.com/watch?v=wHRUtNmPjyE
https://www.youtube.com/watch?v=FWe5uk5NA5I
https://www.youtube.com/watch?v=4RnVwa9TG2g

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

Sampling Theory and Statistical Inference: Sampling, Sampling Distributions, Type I and Type II errors, standard error, Z – test, student's t- distribution, test of hypothesis for means, test for hypothesis for proportions, confidence limits for means, Chi-square distribution as a test of goodness of fit.

Applications: A large number of analyses for process control, product quality control for consumer safety, and environmental control purposes are using Sampling Theory.

Video link / Additional online information **:**
https://www.youtube.com/watch?v=zmyh7nCjmsg
https://www.youtube.com/watch?v=fuBvQJP0ecw&list=PLp6ek2hDcoNCp9o8aLQrbY15a-o0weoTd&index=2
https://www.youtube.com/watch?v=tFRXsngz4UQ
https://www.youtube.com/watch?v=Q1yu6TQZ79w

Course outcomes:	
CO1	Explain the concepts of analytic functions, residues, poles of complex potentials and describe conformal and Bilinear transformation arising in field theory and signal processing.
CO2	Develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, information theory and design engineering
CO3	Apply Z Transform to solve Difference Equation. Use Method of Least Square for appropriate Curves. And Fit a suitable curve by the method of least squares and determine the lines of regression for a set of statistical data.
CO4	Demonstrate testing of hypothesis of sampling distributions and illustrate examples of Markov chains related to discrete parameter stochastic process

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	1
CO3	3	2	0	1	0	0	0	0	0	0	0	1
CO4	3	3	0	3	0	0	0	0	0	0	0	1

High-3, Medium-2, Low-1

Course Title	Chemical Engineering Thermodynamics	Semester	IV
Course Code	MVJ19CH42	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 fundamentals of thermodynamics such as types of properties, processes and laws of thermodynamics for flow and non-flow process.
- Understand the clear concepts on P-V-T behavior, Equations of state, thermodynamic diagrams and compressibility charts, entropy, irreversibility and problem-solving skills.
- Learn the thermodynamic properties of pure fluids, energy relations and fugacity concepts.
- Study the estimation of partial molar properties, property changes of mixing, and ideal and non-ideal solutions.
- Learn the fundamentals of phase equilibrium, concept of chemical potential and chemical reaction equilibrium to find feasibility and extent of conversion for the industrial reactions.

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

BASIC CONCEPTS: System, Surrounding and processes, Closed and Open systems, state and Properties, Intensive and Extensive Properties, State and Path functions, equilibrium state and Phase rule, Zeroth law of thermodynamics, Heat reservoir and Heat engines, Reversible and Irreversible processes.

FIRST LAW OF THERMODYNAMICS: General statement of First law of thermodynamics, First law for cyclic process and non-flow processes, Heat capacity.

HEAT EFFECTS ACCOMPANYING CHEMICAL REACTIONS: Standard heat of reaction, formation, combustion, Hess's law of constant heat summation, effect of temperature on standard heat of reaction.

Laboratory Sessions/ Experimental learning: Demonstrate working of bomb calorimeter to understand the fuel heat capacity measurement

Applications: These concepts are applied to extensive application in chemical engineering. The equilibrium and rate of change can change can be predicted to determine the maximum yield. of the chemical processes.

Video link / Additional online information:

https://nptel.ac.in/courses/103101004/

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

P-V-T BEHAVIOUR:P-V-T behaviour of pure fluids, Equations of state and ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure, constant temperature, adiabatic and polytropic processes. Equation of state for real gases: Vander Waals equation, Redlich – Kwong equation, Peng – Robinson equation, Virial equation, Compressibility charts: Principles of corresponding states, generalized compressibility charts.

SECOND LAW OF THERMODYNAMICS: General statements of the Second law, Concept of Entropy, The Carnot Principle, calculation of entropy changes, Clausius Inequality, Entropy and Irreversibility, Third law of Thermodynamics.

Laboratory Sessions/ Experimental learning:

Explain the concept of entropy with simple reaction

Applications: Application of first law and second law of thermodynamics for fluid flow problems. Estimation the behaviour of real fluids using various equation of state and degree of randomness.

Video link / Additional online information :

https://www.cpalms.org/Public/PreviewResourceLesson/Preview/75658

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

THERMODYNAMIC PROPERTIES OF PURE FLUIDS: Reference Properties, Energy Properties, Derived Properties, Work function, Gibbs free energy, Relationships among thermodynamic properties, Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, Modified equations for U & H, Effect of temperature on U, H & S, Relationships between CP & CV, Gibbs- Helmholtz equation, Fugacity, Fugacity coefficient, Effect of temperature and pressure on Fugacity, Determination of Fugacity of pure gases, Fugacity of solids and liquids, Activity, Effect of temperature and pressure on activity.

Laboratory Sessions/ Experimental learning:

Applications: Evaluation of the thermodynamic properties of pure fluids using measurable quantities like the pressure-Volume temperature relationship.

Video link / Additional online information :

https://nptel.ac.in/content/storage2/courses/103101004/downloads/chapter-5.pdf

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

PROPERTIES OF SOLUTIONS:

Partial molar properties, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, activity in solutions, Activity coefficients, Property changes of mixing, excess properties.

Laboratory Sessions/ Experimental learning: Determination of partial molar volume for different compositions of ethanol –water system.

Applications: Partial molar properties are useful because chemical mixtures are often maintained at constant temperature and pressure and under these conditions, the value of any extensive property can be obtained from its partial molar property. They are especially useful when considering specific properties of pure substances (that is, properties of one mole of pure substance) and properties of mixing (such as the heat of mixing or entropy of mixing)

Video link / Additional online information:

https://www.youtube.com/watch?v=FLRkGbzw0-

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

PHASE EQUILIBRIA: Criteria of phase Equilibria, Criterion of stability, Duhem's theorem, Vapor – Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, VLE at low pressures, VLE at high pressures, consistency test for VLE data, Calculation of Activity coefficients using Gibbs – Duhem's equation.

Laboratory Sessions/ Experimental learning: To generate VLE data for a binary mixture of Acetone and Benzene.

Applications: Thermodynamics of chemical reactions predicts the equilibrium conversion attainable in a chemical reaction and the effect of operating conditions on the degree of completion of the reaction.
Video link / Additional online information:
https://www.chem.uci.edu/~lawm/263%206.pdf

Course Outcomes:	
CO1	Calculate the heat and work requirements for the given flow or non-flow processes.
CO2	Analyse and find properties such as Pressure, Volume and temperature for equations of states and from the fundamentals of first law of thermodynamics.
CO3	Calculate entropy for the processes, and various types of energies such as internal energy, enthalpy, Helmholtz free energy and Gibbs free energy.
CO4	Differentiate between ideal and non-ideal solution and estimate partial molar properties.
CO5	Identify the role of thermodynamics in the design and operation of chemical reaction system.

Reference Books:	
1.	Smith J.M. and Vanness H.C., "Introduction to Chemical Engineering Thermodynamics", 5th edn., McGraw Hill, New York, 1996
2.	Rao Y.V.C., "Chemical Engineering Thermodynamics", New age International Publication, Nagpur, 2000
3	Narayanan K.V., "Text book of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.
4	**Web Link and Video Lectures:** https://nptel.ac.in/courses/103101004/

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

High-3, Medium-2, Low-1

Course Title	Chemical Reaction Engineering-1	Semester	IV
Course Code	MVJ19CH43	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 the scope of Chemical reaction Engineering.
- Analyze and interpret the experimental data to determine kinetic rate equation and understand the design of ideal reactor systems.
- Understand the concept of non-isothermal reactors.

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

Introduction to Chemical Reactions. Homogeneous and heterogeneous reactions with their basic definitions, Elementary and non-elementary reactions, reaction rate and rate constant, order and molecularity of a reaction, Temperature dependency of rate constant and kinetic modelling: Arrhenius, collision and transition state theories.
Non-Elementary Reactions: Difference between elementary and non- Elementary reactions. Kinetic models and mechanisms for non- Elementary reactions.

Laboratory Sessions/ Experimental learning: Demonstration of Homogeneous and heterogenous reactions and effect of temperature on reaction rate.
Applications: Calculations of reaction rate constants using kinetic theories for a given experimental data
Video link / Additional online information:
https://nptel.ac.in/courses/103106116/

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

Single Reactions: Interpretation of experimental data using Integral method and differential method, constant volume and variable volume reactions, half-life method. Numerical problems.
Types of reactors: Batch, Semi-batch, laminar, and mixed flow reactors. Multiphase reactors of Industrial Importance (fixed, fluidized and bubble column reactors) and their practical demonstration.

Laboratory Sessions/ Experimental learning: Practical demonstration of fixed-bed, fluidized bed and bubble column reactor types.
Applications: Industrially important reactor types

Video link / Additional online information :
http://encyclopedia.che.engin.umich.edu/Pages/Reactors/PBR/PBR.html
https://www.youtube.com/watch?v=AzK7K601cAE

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

Design of reactors: Design of Batch, Semi-batch, laminar and mixed flow ideal reactors and their performance equations. Constant volume and variable volume reactors. Design of batch reactor, PFR and MFR. Space time and space velocity, Holding time for flow reactors. Size comparison of ideal reactors. Numerical problems.

Laboratory Sessions/ Experimental learning:
Virtual demonstration of reaction kinetic studies in batch reactor, PFR and MFR.
Applications: Design of industrial reactors.
Video link / Additional online information : http://uorepc-nitk.vlabs.ac.in/#
https://www.youtube.com/watch?v=ftnLJ6VDwS8

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

Multiple Reactor Systems: Plug flow and /or Mixed flow reactors in Series, parallel and series-parallel. Reactors of different types and sizes in series. Design of Reactors for Multiple Reactions: Design of Batch reactor, Plug and Mixed flow reactors for Parallel, Series and Series- Parallel reactions (Only irreversible reactions must be considered).

Laboratory Sessions/ Experimental learning: PFR and MFR in series operation
Applications: Working and designing of multiple reactor system
Video link / Additional online information :
https://www.youtube.com/watch?v=puJXBMtB4W4 https://www.youtube.com/watch?v=SVfs9JzMYoc
https://www.youtube.com/watch?v=TleC05u13fI

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

CHEMICAL REACTION EQUILIBRIUM: Reaction Stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant and standard free energy change, Effect of temperature, Pressure on equilibrium constants and other factors affecting equilibrium conversion, Liquid phase reactions, heterogeneous reaction equilibrium, phase rule for reacting systems.

Non-Isothermal Reactors: Introduction, effect of temperature on equilibrium constant and heat of reaction, Material and Energy balances, conversions in adiabatic and non-adiabatic reactors.

Analysis of Non-Isothermal Reactor: Design procedure for single reactions, Optimum temperature Progression, Safety concepts for non-isothermal reactors. Numerical problems.

Laboratory Sessions/ Experimental learning: To analyze the conversion in an adiabatic reactor.
Applications: Equilibrium studies on reactive processes help to understand the feasibility and maximum possible yield of the desired product at any given conditions.
Non-isothermal reactor systems studies will help to design a reactor and predict conversions under non-isothermal conditions.
Video link / Additional online information:
https://www.youtube.com/watch?v=WCbnTMBo4Co

Course Outcomes:	
CO1	Explain various types of reactions, factors affecting rate equation, theories for predicting temperature dependency of rate constant and kinetics.
CO2	Interpret experimental data using differential, integral, and half-life methods, and types of chemical reactors with real practise.
CO3	Develop design equations for ideal reactors for constant and variable volume reactions and generating kinetic data in ideal reactors.
CO4	Develop the design of single and multiple reactor systems and reactions.
CO5	Design non isothermal reactors and discuss optimum temperature progression.

Reference Books:	
1.	Chemical Reaction Engineering, Octave Levenspiel, 3rd Edition, 2004, ISBN 9780471254.
2.	Elements of Chemical Reaction Engineering, H.Scott Fogler, 5th Edition, 2016, ISBN 9780133887822.
3	Chemical Engineering Kinetics, J M Smith, 3rd Edition, 1981, ISBN 9780070587106.
4	**Web Link and Video Lectures:** 1. https://nptel.ac.in/courses/103106116/ 2. http://umich.edu/~elements/5e/lectures/index.html

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

High-3, Medium-2, Low-1

Course Title	Chemical Technology	Semester	III
Course Code	MVJ19CH44	CIE	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	SEE	50
No. of Contact Hours/week	5	Total	100
Credits	3	Exam. Duration	3 hrs

Course objective is to:

- Understand the basic concepts of Industrial Processes practiced in different Inorganic & Organic Chemical Industries.
- Get insight in to the safety and environmental management schemes practiced.
- Assess different engineering problems of individual processes.
- Understand the plant layout and equipment used in the processes

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

Symbolic Representation of different unit operations and processes to build a flow sheet.

INDUSTRIAL GASES AND ACIDS:

Industrial Gases: CO_2, H_2, O_2, N_2, SO_2, SO_3.

Industrial Acids: Sulphuric, Nitric, Hydrochloric and Phosphoric Acids.

WATER: Introduction, impurities in water, soft water-hard water, causes of hardness, disadvantages of hard water, measurement of hardness, methods of softening of water, purification of water, treatment of boiler feed water.

SOAPS AND DETERGENTS: Soaps and detergents, theory of detergency.

Laboratory Sessions/ Experimental learning: Estimate Softness and hardness of wastewater by conducting standard analysis.

Applications: Students can estimate the hardness of water and also can evaluate various parameters for checking the quality of water.

Video link / Additional online information:

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

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

FERMENTATION INDUSTRIES: Production of alcohol, Manufacture of beer, wines and liquors.

OILS, FATS, WAXES: Vegetable and animal oils and fats. Extraction of vegetable oils, refining of edible oils. Hydrogenation of oils, waxes and their applications.

Laboratory Sessions/ Experimental learning: Demonstrate an experiment for production of alcohol by fermentation technology.

Applications:

Production of alcohol, extraction of vegetable oil and chemical processes associated with it can be studied.

Video link / Additional online information:

https://www.youtube.com/watch?v=lcXnWrDZV6Q

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

CHLOR-ALKALI AND CEMENT INDUSTRIES:

Sodium chloride, Soda ash, Caustic soda, Chlorine. Cement industries: Classification, manufacture, reactions, flow diagrams, major and minor engineering problems, applications.

APPLICATIONS OF MICROELECTRONICS IN CHEMICAL INDUSTRIES: Purification and refining of silicones, Chemical Mechanical Planarization (CMP)

Laboratory Sessions/ Experimental learning:

To determine the energy required for crushing the sample and working of Ball mills and jaw crushers. Also determine the reduction ration and critical speed of the mill

Applications:

Ball mill and crushers are used in Cement industries for reducing the size of particles.

Video link / Additional online information:

https://www.youtube.com/watch?v=dAD03D5cTF8

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

MODULE-4: PETROLEUM INDUSTRIES AND PETROCHEMICALS: Origin and classification. Petroleum refining and processing

COAL: Formation and Classification of coal, mining of coal, destructive distillation of coal, coking of coal, coal tar distillation, chemicals from coal.

PULP AND PAPER INDUSTRIES: Raw materials, manufacture of pulp, paper and its major engineering problems.

Laboratory Sessions/ Experimental learning: Demonstration of various unit operations and processes in production plants.

Applications: Basic concepts of unit operations and processes can be understood which finds applications in treatment and production of paper in industries.

Video link / Additional online information:

https://www.youtube.com/watch?v=E4C3X26dxbM

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

MODULE-5: INORGANIC FERTILIZERS: Ammonia, urea, ammonium phosphate, ammonium nitrate, ammonium sulphate, DAP, phosphorous pentoxide, super phosphate and triple super phosphate.

POLYMERS & RUBBER: Macromolecules. Polymerization. PVC, LDPE. Polypropylene. Natural rubber.

Laboratory Sessions/ Experimental learning:

Exhibit the polymerization reactions by conducting experiment with simple monomers.

Applications:

Various types of polymerization can be studied for production of polymers.

Video link / Additional online information:

https://www.youtube.com/watch?v=JIV4ZX1Uh_4

Course Outcomes:	
CO1	Explain the basic processes for manufacture of industrial gases, acids, Soaps and Detergents also sources, impurities and treatment methods of water.
CO2	Get insight of cement manufacture, fermentation products and basic concepts of industrial processes practiced in the manufacture of Oils, Fats, and Waxes.
CO3	Outline the manufacture of Chlor-alkali and Cement industries
CO4	Explain the refining of petroleum, formation, classification of coal, destructive distillation of coal and manufacture of pulp and paper.
CO5	Learn industrial scale operations and processes employed in manufacture of fertilizers & polymers and rubber.

Reference Books:	
1.	Shreve's Chemical Process Industries, 4th edn, McGraw Hill.
2.	Dryden – Outlines of Chemical Technology for 21st Century, Gopal Rao & Marshall Sittig, 3rd edn. EWP.
3	Unit Processes in Organic Chemical Industries, Desikan and Sivakumar (Eds.), CEDC, IITM, 1982.
4	Encyclopedia of Chemical Technology, Kirk and Othmer, 27th volume, 5th edn, Wiley, 2004.
5	**Web Link and Video Lectures:** https://swayam.gov.in/nd1_noc19_ch19/preview https://swayam.gov.in/nd1_noc19_cy20/preview https://nptel.ac.in/courses/103107082/ https://nptel.ac.in/courses/103103029/

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	Process Heat Transfer	Semester	IV
Course Code	MVJ19CH45	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 various modes of Heat transfer and their fundamental relations.
- Study conduction heat transfer and develop mathematical relations for various solid geometries.
- Understand different types of heat transfer coefficients and their estimations in various types of flows in different geometries.
- Study the Boiling phenomenon and to generate pool boiling curve.
- Understand the working and basic design of Heat exchangers
- Understand the phenomenon of radiation, radiation shields and estimation of emissivity.

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

INTRODUCTION: Importance of heat transfer in Chemical Engineering operations, Modes of heat transfer

CONDUCTION: Fourier's law, Steady state unidirectional heat flow through single and multiphase layers slabs, cylinders and spheres for constant and variable thermal conductivity. - Thermal conductivity measurement-effect of temperature on thermal conductivity, Properties of insulation materials, Types of insulation, Critical and Optimum thickness of insulation, Numerical Problems.

Laboratory Sessions/ Experimental learning: Determine the thermal resistance of the composite wall and determine the thermal conductivity of each material of the composite wall.

Applications: This kind of composite materials/walls are used in industrial furnaces, air crafts, trains, marines and other thermal engineering applications.

Video link / Additional online information:

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

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

EXTENDED SURFACES: Types of fins, fin efficiency for longitudinal fins, Fin effectiveness, Numerical Problems.

CONVECTION: Individual and overall heat transfer coefficient, LMTD, LMTD correction factor, Dimensionless numbers, Dimensional analysis, Empirical correlation for forced and natural convection, Analogy between momentum and heat transfer-Reynold, Colbourn, Prandtl analogies. Numerical Problems.

Laboratory Sessions/ Experimental learning: Study the heat transfer in extended (finned) tube under natural convection using the experimental set up in heat transfer lab

Applications: Fins are widely used in many applications such as heating, ventilation and air conditioning system, finned tube heat exchangers, solar systems and electrical systems.

Video link / Additional online information:

https://www.youtube.com/watch?v=SNnd0f3xXlg

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

HEAT TRANSFER WITH PHASE CHANGE:
Heat transfer to fluids with phase change - heat transfer from condensing vapours, drop wise and film wise condensation, Nusselt equation for vertical and horizontal tubes, condensation of superheated vapours, effect of non-condensable gases on rate of condensation. Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling, Numerical Problems.

Laboratory Sessions/ Experimental learning: An experiment to determine the convective heat transfer coefficient in condensation process.
Applications: All chemical industries, thermal and nuclear power generation in steam plants, refrigeration, refining, heat transmission, etc
Video link / Additional online information:
https://www.youtube.com/watch?v=j-TXp789inU

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

RADIATION: Properties and definitions, Emissive power and intensity of radiation, Black body radiation, Grey body radiation, Stefan – Boltzmann law, Wein's displacement law, Kirchhoff's law, radiation shape factor, radiation between large parallel plates, Numerical Problems.

Laboratory Sessions/ Experimental learning: Demonstrate how to determine the emissivity of a given grey body.

Applications: Emissivity is important in solar heat collectors, thermal shielding pyrometers and insulated windows.
Video link / Additional online information:
https://www.youtube.com/watch?v=pbCf4507QvM

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

HEAT TRANSFER EQUIPMENT: Double pipe heat exchanger. Shell and tube heat exchangers, Condensers, Construction and working, Types of shell and tube heat exchangers, type of condensers.
DESIGN OF HEAT TRANSFER EQUIPMENT: Elementary design of double pipe heat exchanger. Shell and tube heat exchanger and condensers, Numerical Problems.

EVAPORATION: Single and multiple effect operation, material and energy balance in evaporators, forward and backward feeds, capacity and economy of evaporators, Multiple effect evaporator – Methods of feeding.
Laboratory Sessions/ Experimental learning: Exhibit the working of heat exchangers, condensers, evaporators and boilers to get the complete understanding of the constructional details.
Applications: They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment.

Video link / Additional online information:
https://www.youtube.com/watch?v=r67f4V6pOOw

Course Outcomes:	
CO1	Develop flux equations for steady state heat conduction and critical thickness of insulation in different geometry of solids.
CO2	Explain the types of fins, fin effectiveness and apply various correlations of convective heat transfer to different problems
CO3	Derive the Nusselt equation for heat transfer with phase change.
CO4	Interpret the phenomenon of radiation in different types of solids.
CO5	Develop the elementary design equations for various Heat exchangers

Reference Books:	
1.	Kern D.Q., "Process Heat Transfer", McGraw Hill., New York, 1965
2.	McCabe W.L., *et.al*., "Unit Operations of Chemical Engineering", 5thedn., McGraw Hill, New York, 2000
3	Coulson J.M. and Richardson J.F., "Unit Operations of Chemical Engineering", Vol-I, 5thedn., Chemical Engg, Pergamon & ELBS, McGraw Hill, New York, 2000
4	Rao Y.V.C., "Heat Transfer", 1stedn. Universities Press (India) Ltd., New Delhi, 2001.
6	Dutta, Binay K., "Heat Transfer: Principles and Applications", PHI Learning. 2000
	Web Link and Video Lectures: https://nptel.ac.in/courses/103103032/

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	1
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	3	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	Instrumental Analysis	Semester	IV
Course Code	MVJ19CH46	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10 : 10	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	03	**Exam. Duration**	3 hrs

Course objective is to:		
The course is designed to impart the knowledge in the field of Instrumental Analysis. The various modern analytical techniques like UV-Visible, IR, NMR, Mass, GC, HPLC, different chromatographic methods and other important topics are taught to enable the students to understand and apply the principles involved in the determination of different bulk drugs and their formulation. In addition to the theoretical aspects, the basic practical knowledge relevant to the analysis is also imparted.		
Module-1	**RBT Level;** L1, L2 & L3	12 Hrs.
CHROMATOGRAPHY: Introduction, classification of chromatographic methods based on the mechanism of separation. Column Chromatography: Adsorption and partition, theory, preparation, procedure and methods of detection. Thin Layer Chromatography: Theory, preparation, procedures, detection of compounds. Paper Chromatography: Theory, different techniques employed, filter papers used, qualitative and quantitative detection. Counter – current extraction, solid phase extraction techniques, gel filtration. Laboratory Sessions/ Experimental learning: Analysis of compound using solvent by TLC method. Applications: For separation of mixture of components present in a compound Video link / Additional online information: https://www.youtube.com/watch?v=462CmolEFhc		
Module-2	**RBT Level;** L1, L2 & L3	12 Hrs.
GAS CHROMATOGRAPHY: Introduction, fundamentals, instrumentation, columns: preparation and operation, detection, dramatization. **Liquid Chromatography:** HPLC: Principles and instrumentation, solvents and columns, detection and applications. Laboratory Sessions/ Experimental learning: Demonstration of analysis of compound by Gas chromatography can be observed in video. Applications: Gas chromatography used in analytical chemistry for separating and analysing compounds. Video link / Additional online information: https://www.youtube.com/watch?v=ZpPzImDSfqc		

<table>
<tr><th>Module-3</th><th>RBT Level;
L1, L2 & L3</th><th>12
Hrs.</th></tr>
<tr><td colspan="3">SPECTROSCOPY: Introduction, electromagnetic spectrum.
UV-Visible spectroscopy: absorbance laws and limitations, instrumentation-design and working principle, chromophore and autochromes concept, Wood-Fisher rules for calculating absorption maximum, applications of UV-Visible spectroscopy.
IR spectroscopy: Basic Principles-Molecular vibrations, vibrational frequency, factors influencing vibrational frequencies, sampling techniques, instrumentation, interpretation of spectra, FT-IR, theory and applications.

Laboratory Sessions/ Experimental learning: Analysis of organic compounds using UV-Visible spectroscopy
Applications: UV/Vis spectroscopy is routinely used in analytical chemistry for the quantitative determination of different analytes.
Video link / Additional online information:
https://www.youtube.com/watch?v=1FQPXtN7MeI</td></tr>
<tr><th>Module-4</th><th>RBT Level;
L1, L2 & L3</th><th>12
Hrs.</th></tr>
<tr><td colspan="3">MASS SPECTROSCOPY: Theory, ionization techniques: electron impact ionization, chemical ionization, field ionization, fast atom bombardment, plasma desorption, fragmentation process: types of fission, resolution, GC/MS, interpretation of spectra and applications for identification and structure determination.
X-RAY DIFFRACTION (XRD): Bragg's law, basic powder diffraction, generation of X-rays, instrumentation, Scherrer equation, BCC and FCC Bravais lattice, phase identification using XRD.

Laboratory Sessions/ Experimental learning: Interpretation of mass spectrum using Mass spectroscopy.
Applications: This method is used to determine the elemental or isotopic signature of a sample, the masses of molecules, and to elucidate the chemical structure of molecules or their chemical compounds.
Video link / Additional online information:
https://www.youtube.com/watch?v=8YKhiG25lcg</td></tr>
<tr><th>Module-5</th><th>RBT Level;
L1, L2 & L3</th><th>12
Hrs.</th></tr>
<tr><td colspan="3">NMR: Theory, instrumentation, chemical shift, shielding and de-shielding effects, splitting of signals, spin-spin coupling, proton exchange reactions, coupling constant (J), nuclear over Hauser effect (NOE), 1HNMR, 13CNMR spectra and its applications.

Laboratory Sessions/ Experimental learning:
Interpretation of NMR spectrum of different organic compounds using NMR spectroscopy
Applications: NMR analysis is useful for shape and structure of compounds.
Video link / Additional online information:
https://www.youtube.com/watch?v=LBHXbh3unBs</td></tr>
</table>

Course outcomes:	
CO1	Discuss classification of chromatography and explain Thin Layer, Gas Chromatography and High-Performance Liquid Chromatographic methods
CO2	Discuss types of spectroscopy, instrumentation and applications of UV Spectroscopy
CO3	Explain theory, instrumentation and applications of IR spectroscopy
CO4	Discuss principle, instrumentation and applications of Mass Spectroscopy and NMR spectroscopy
CO5	Discuss principle, instrumentation and applications of X-ray diffraction

Reference Books:	
1.	Instrumental Methods of Chemical Analysis by B.K. Sharma
2.	Organic Spectroscopy by Y.R Sharma
3.	Text book of Quantitative Chemical Analysis by Vogel's A.I.
4.	Organic Spectroscopy by William Kemp

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

High-3, Medium-2, Low-1

Course Title	Chemical Engineering Drawing Lab	Semester	IV
Course Code	MVJ19CHL47	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:

Draw the the proportionate drawings of reaction vessel, jacked vessels, evaporator, STHE and also the assembly drawings of socket and spigot, flanged pipe and union joints etc with the help of solid edge software.

Experiments:	**RBT Level;** L1, L2 & L3	40Hrs.

SECTIONAL VIEWS:

Representation of the sectional planes, Sectional lines and hatching, selection of section planes and types of sectional views.

PROPRTIONATE DRAWINGS

Equipment and piping symbols, Vessels components: Vessel openings, Manholes, Vessel enclosures, Vessel support, Jackets, Shell and tube heat exchanger, Reaction vessel with the help of solid edge software and different types of Evaporators. P & I Diagrams

ASSEMBLY DRAWINGS:

Joints: Cotter joint with sleeve, Socket and Spigot joint, Flanged pipe joint, Union joint, Stuffing box and Expansion joint (Screw type or flanged type).

Demonstration: Additive manufacturing, 3D-Printing, and 3D-printer

Note:

- Assignments to be given to students to practice all the drawings and weightage shall be given to these assignments while awarding IA marks.
- Minimum of Ten drawings are to be conducted.
- Examination consists of one question on proportionate drawing (30 marks) and one question on Assembly drawing (70 marks).
- Examination to be conducted like other lab exams. Question paper should be prepared jointly by Internal and External examiners.
- Computer Aided drawing Software: Solid Edge or Equivalent Software.

Course Outcome:	
CO1	Draw the general projections of given object.
CO2	Represent two-dimensional proportionate drawings of process symbols of various pipes and fittings.
CO3	Draw the proportionate drawings of reaction vessel, jacked vessels, evaporator, STHE and DPHE
CO4	Draw the assembly drawings of socket and spigot, flanged pipe and union joints showing sectional, front, top, and side views.
CO5	Demonstrate the usage of solid edge software tool for engineering drawing.

Reference Books:	
1.	Gopal Krishna K.R., "Machine Drawing", 2nd revised edn., Sudhas stores, Bangalore, 1998
2.	Bhat N.D., "Machine Drawing", 22ndedn., Charoter Publishing House, Anand, 1987
3	Joshi M.V., "Process Equipment Design", 3rdedn., Macmillan India publication", New Delhi, 1999
4	Walas S.M., "Chemical Process Equipment", Butterworth Heinemann Pub., 1999
5	Ludwig E.E., "Applied Process Design", 3rdedn., Gulf Professional Publishing, New Delhi, 1994

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

High-3, Medium-2, Low-1

Course Title	Mechanical Operations Lab	Semester	IV
Course Code	MVJ19CHL48	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:

Analyse the efficiency of various size reduction equipment's, Average particle size analysis, and to evaluate filtration and sedimentation processes

Experiments:	**RBT Level;** L1, L2 & L3	40Hrs.

1. Ball mill- verify the crushing laws using given sample
2. Batch sedimentation- determine area of thickener required for given sample
3. Free settling- determine settling velocity of various samples
4. Drop weight crusher- verify the crushing laws using given sample.
5. Sieve analysis-find the particle size distribution of the given sample
6. Screen effectiveness-find the separation efficiency of given screen.
7. Jaw crusher- verify the crushing laws using given sample.
8. Leaf filter-find the specific cake resistance
9. Air elutriation - find the particle size distribution of the given sample
10. Air permeability- find the specific surface area of the particles of a given sample
11. Grindability index
12. Froth floatation- Efficiency of frothing agent in separating given ore sample.
13. Plate and frame filter press - find the specific cake resistance
14. Cyclone separator- Efficiency of separation

Minimum of 10 experiments are to be conducted

Course Outcome

CO1	Explain properties of particulate solids, handling and mixing of solid particles.
CO2	Analyse principles and different types of size reduction equipment's like crushers, grinders etc.
CO3	Evaluate the effectiveness of screening, filtration, sedimentation, of solids etc.
CO4	Evaluate energy requirements in solids handling, agitation and mixing, solid conveying storage.
CO5	Conduct experiments on some of the basic unit operations such as separation and size reduction.

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

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	2	2	2	2	0	0	0	0	0	0	0	0
CO3	2	2	2	2	0	0	0	0	0	0	0	0
CO4	2	2	2	0	0	0	0	0	0	0	0	0
CO5	2	2	2	2	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1