Semester: IV		
COMPLEX ANALYSIS, PROBABILITYAND SAMPLING THEORY (Theory)		
Course Code:	MVJ21MA41C	CIE Marks:50
Credits: L:T:P:	2:2:0	SEE Marks: 50
Hours:	50L	SEE Duration: 3 Hrs
Course Learning Objectives: The students will be able to		
1	Understand the concepts of Complex variables and transformation for solving EngineeringProblems.	
2	Understand the concepts of complex integration, Poles, and Residuals in the stability analysis ofengineering problems.	
3	Use statistical methods in curve fitting applications.	
4	To understand the probability distribution in civil and chemical engineering.	
5	Understand the concepts of Sampling theory in science and engineering.	

UNIT-I	
Complex variables - I: Functions of complex variables (Review), Analytic function, Cauchy-Riemann Equations in Cartesian and polar coordinates, Construction of analytic functions (Using Milne-Thomson method). **Transformations:** Bilinear Transformation, Conformal transformation, Discussion of the transformation $w = z^2, w = e^z and\ w = z + \frac{1}{z}(z \neq 0)$	10 Hrs
UNIT-II	
Complex variables-II: Complex integration - Cauchy theorem, Cauchy's Integral Theorem-Problems, Taylor & Laurent series- Problems, Singularities, Types of Singularities, Poles, Residues-definitions, Cauchy residue theorem (without proof) - Problems.	10 Hrs
UNIT-III	
Statistical Methods: Introduction, Correlation and coefficient of correlation, Regression - line of regression problems.Curve Fitting: Curve fitting by method of least squares- fitting of the curves of the form, $y = ax + b, y = ax^2 + bx + c\ and\ y = ae^{bx}$.	10 Hrs
UNIT-IV	
Probability Distributions: Random variables (discrete and continuous), probability mass/density functions. Binomial distribution, Poisson distribution, Geometric distribution and normal distributions - problems. Joint probability distribution: Joint Probability distribution for two discrete random variables,expectation, covariance.	10 Hrs
UNIT-V	
Sampling Theory and Statistical Inference: Sampling, Type I and Type II errors, standard error, confidence limits, test of hypothesis for means,	10 Hrs

test for hypothesis for proportions, student's t- distribution, Chi-square distribution as a test of goodness of fit.	

Course Outcomes: After completing the course, the students will be able to	
CO1	State and prove Cauchy - Riemann equation with its consequences and demonstrate Con-formal Transformation.
CO2	Illustrate Complex Integration using Cauchy's Integral theorem, Cauchy's Integral formula and Cauchy's Residue theorem.
CO3	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	Develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, information theory anddesign engineering
CO5	Demonstrate testing of hypothesis of sampling distributions and illustrate examples related to discrete parameters.

Reference Books	
1.	Engineering Mathematics-III, Prof G.B.Gururajachar, 2016-17, Academic Excellent series Publications.
2.	Higher Engineering Mathematics, B.S. Grewal, 2013, 44th Edition, Khanna Publishers.
3.	Advanced Engineering Mathematics, Erwin Kreyszig, 2014, 10th edition, Wiley-India publishers.
4.	Higher Engineering Mathematics, Ramana B. V., 2006, Tata McGraw-Hill.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part-A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have

internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	3	3	--	3	--	--	--	--	--	--	1	--
CO2	3	3	--	3	--	--	--	--	--	--	--	1
CO3	2	3	--	3	--	--	--	--	--	--	1	--
CO4	3	3	--	3	--	--	--	--	--	--	--	--
CO5	3	3	--	2	--	--	--	--	--	--	--	1

High-3, Medium-2, Low-1

Semester: IV		
CHEMICAL ENGINEERING THERMODYNAMICS (Theory)		
Course Code:	MVJ21CH42	CIE Marks: 50
Credits: L:T:P:	2:2:0	SEE Marks: 50
Hours:	40L	SEE Duration: 3 Hrs.
Course Learning Objectives: The students will be able to		
1	Learn fundamentals of thermodynamics such as types of properties, processes, and laws of thermodynamics for flow and non-flow process.	
2	Understand the clear concepts on P-V-T behavior, Equations of state, thermodynamic diagrams and compressibility charts, entropy, irreversibility, and problem-solving skills.	
3	Learn the thermodynamic properties of pure fluids, energy relations and fugacity concepts.	
4	Study the estimation of partial molar properties, property changes of mixing, and ideal and non-ideal solutions.	
5	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.	

UNIT-I	
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.	8 Hrs
UNIT-II	
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.	8 Hrs
UNIT-III	
Thermodynamic Properties of Pure Fluids: Reference properties,	8 Hrs

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 C_P & C_V, 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.	
UNIT-IV	
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.	8 Hrs
UNIT-V	
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.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
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., Van Ness, H. C., & Abbott, M. M. (1987). Introduction to Chemical Engineering Thermodynamics, McGraw Hill. Inc.: New York.
2	Rao, Y. V. C. (1997). Chemical Engineering Thermodynamics. Universities Press.
3	Narayanan, K. V. (2004). A Textbook of Chemical Engineering Thermodynamics. PHI Learning Pvt. Ltd.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	2	3	3	--	--	--	--	--	--	--	--	--
CO2	2	3	3	2	--	--	--	--	--	--	--	--
CO3	2	3	3	2	--	--	--	--	--	--	--	--
CO4	2	3	3	--	--	--	--	--	--	--	--	--
CO5	2	3	3	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Semester: IV		
CHEMICAL PROCESS INDUSTRIES (Theory)		
Course Code:	MVJ21CH43	CIE Marks: 50
Credits: L:T:P:	3:0:0	SEE Marks: 50
Hours:	40L	SEE Duration: 3 Hrs.
Course Learning Objectives: The students will be able to		
1	Understand the basic concepts of Industrial Processes practiced in different Inorganic & Organic Chemical Industries.	
2	Get insight into the safety and environmental management schemes practiced.	
3	Assess different engineering problems of individual processes.	
4	Understand the plant layout and equipment used in the processes.	

UNIT-I	
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.	8 Hrs
UNIT-II	
Cement industries: Classification, manufacture, reactions, flow diagrams, major and minor engineering problems, applications. **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.	8 Hrs
UNIT-III	
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.	8 Hrs
UNIT-IV	
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.	8 Hrs
UNIT-V	
Inorganic fertilizers: Ammonia, urea, ammonium phosphate, ammonium nitrate, ammonium sulphate, DAP, phosphorous pentoxide,	8 Hrs

super phosphate and triple super phosphate. **Polymers & Rubber**: Macromolecules. Polymerization. PVC, LDPE. Polypropylene. Natural rubber.	

Course Outcomes: After completing the course, the students will be able to	
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	Outlines of chemical technology, Dryden, C. E., Rao, M. G., & Sittig, M., 1973, Affiliated East-West P..
2	Chemical Process Industries, Shreve, R. N., & Brink Jr, J. A., 1977, 4th Edition, McGraw-Hill Book Co..
3	Encyclopedia of chemical technology, Kroschwitz, J. I., Howe-Grant, M., Kirk, R. E., & Othmer, D. F., 1996, John Wiley & Sons.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: IV		
PROCESS HEAT TRANSFER (Theory and Practice)		
Course Code:	MVJ21CH44	CIE Marks:50+50
Credits: L:T:P:	2:2:2	SEE Marks: 50 +50
Hours:	40 L+ 26 P	SEE Duration: 03+03 Hrs
Course Learning Objectives: The students will be able to		
1	Study various modes of Heat transfer and their fundamental relations.	
2	Understand different types of heat transfer coefficients and their estimations in various types of flows in different geometries.	
3	Study the Boiling phenomenon and to generate pool boiling curve.	
4	Understand the working and basic design of Heat exchangers.	
5	Understand the phenomenon of radiation, radiation shields and estimation of emissivity.	

UNIT-I	
Introduction: the 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, the critical and optimum thickness of insulation.	8 Hrs
UNIT-II	
Extended Surfaces: types of fins, fin efficiency for longitudinal fins, fin effectiveness. **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.	8 Hrs
UNIT-III	
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 vapors, effect of non-condensable gases on rate of condensation. Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling.	8 Hrs
UNIT-IV	
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.	8 Hrs
UNIT-V	
Heat Transfer Equipment: double pipe heat exchanger. shell and tube	8 Hrs

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. **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 EXPERIMENTS	
1	Bare tube heat exchanger
2	vertical shell and tube heat exchanger (Condenser)
3	Horizontal Shell and tube Heat exchanger (Condenser)
4	Helical Coil Heat exchanger
5	An emissivity of grey surface
6	Heat transfer coefficients in a packed bed
7	Double pipe Heat exchanger
8	Heat transfer in a jacketed vessel
9	Transient heat conduction
10	Heat Transfer in Fluidized Beds
11	Single effect evaporator
12	Spiral plate heat exchanger
13	Cross flow heat exchanger
14	Finned tube heat exchanger
15	Stefan Boltzmann constant for radiation heat transfer
16	Experiment to verify Fourier's law
Any 12 experiments to be conducted	

Course Outcomes: After completing the course, the students will be able to	
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.	Unit operations of Chemical Engineering, McCabe, W. L., Smith, J. C., & Harriott, P., 1993, McGraw-Hill.
2.	Heat Transfer, Rao, Y.V.C, 2002, Universities Press.
3.	Fluid Flow, Heat Transfer and Mass Transfer, Coulson J.M, Richardson J.F, Backhurst JR and Harker J.H., 2002, 5th ed., Elsevier.
4.	Heat transfer: principles and applications, Dutta, B. K., 2000, PHI Learning.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the self -study are 20 (2 presentations are be held for 10 marks each). The marks obtained in test, quiz and self -studies are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: IV		
CHEMICAL REACTION ENGINEERING (Theory and Practice)		
Course Code: MVJ21CH 45		CIE Marks:50+50
Credits: L:T:P 2:2:2		SEE Marks: 50 +50
Hours:40 L+ 26 P		SEE Duration: 03+03 Hours

Course Learning Objectives: The students will be able to	
1	Understand the scope of Chemical Reaction Engineering.
2	Analyze and interpret the experimental data to determine kinetic rate equation and understand the design of ideal reactor systems.
3	Understand the concept of non-isothermal reactors.
4	Understand and apply the principles of non-ideal flow in the design of reactor.

UNIT-I	
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. **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.	8 Hrs
UNIT-II	
Design of Reactors: Design of Batch, Semi-batch, and mixed flow ideal reactors and their performance equations. Constant volume and variable volume reactors. Space time and space velocity, Holding time for flow reactors. Size comparison of ideal reactors.	8 Hrs
UNIT-III	
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).	8 Hrs
UNIT-IV	
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. **Basics of Non-Ideal Flow**: importance & interpretation of RTD, C, E & F curves & statistical interpretation. dispersion model. tanks in series model. conversion in non-ideal flow reactors for simple systems.	8 Hrs
UNIT-V	

Catalysis: introduction to catalysis. properties of catalysts. estimation methods for catalytic properties. promoters, inhibitors etc, mechanism of catalysis. rate equations for different rate controlling step. **Deactivation:** deactivating catalyst.	8 Hrs

LABORATORY EXPERIMENTS
1. Interpreting isothermal batch reactor experimental data using the Integral method of analysis. 2. Performing saponification reaction in an isothermal plug flow reactor 3. Performance of an isothermal mixed flow reactor 4. Study the performance of a semi-batch reactor for a saponification reaction 5. Degradation kinetics of dye in a photochemical reactor. 6. Performing esterification reaction in an adiabatic batch reactor. 7. Performing saponification reaction in a packed bed reactor. 8. RTD studies in Tubular reactor 9. Effect of temperature on Rate of reaction 10. RTD Studies in mixed flow reactor. 11. Degradation kinetics of dye in a sonochemical reactor. 12. Estimating Physico-chemical properties of a catalyst.
12 experiments to be conducted

Course Outcomes: After completing the course, the students will be able to	
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 practice. and Develop design equations for ideal reactors.
CO3	Develop the design of single and multiple reactor systems and non-isothermal reactors and discuss optimum temperature progression.
CO4	Interpret non ideality in a reactor using RTD data and predict conversion using various models like Dispersion and tanks in series model.
CO5	Derive the rate expressions for heterogeneous catalytic reactions and Catalytic deactivation

Reference Books	
1.	Chemical reaction engineering, Levenspiel, O., 1998, 3rd ed. John wiley & sons.
2.	Elements of Chemical Reaction Engineering, Fogler, H.S., 2010, 4th ed, Pearson New International Edition.
3.	Chemical engineering kinetics, Smith, J. M., 1981, 3rd ed. McGraw-Hill.
4.	Chemical and catalytic reaction engineering, Carberry, J. J., 2001, Dover.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the self -study are 20 (2 presentations are be held for 10 marks each). The marks obtained in test, quiz and self -studies are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

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

High-3, Medium-2, Low-1

Semester: IV		
CONSTITUTION OF INDIA AND PROFESSIONAL ETHICS AND CYBER LAW (Theory)		
Course Code: MVJ21CPH46		CIE Marks:50
Credits: L:T:P: 1:0:0		SEE Marks: 50
Hours: 15L		SEE Duration: 3 Hrs
Course Learning Objectives: The students will be able to		
1	To know the fundamental political codes, structure, procedures, powers, and duties of Indian constitution, Indian government institutions, fundamental rights, directive principles and the duties of the citizens.	
2	To provide overall legal literacy to the young technograts to manage complex societal issues in the present scenario.	
3	To understand engineering ethics & their responsibilities, identify their individual roles and ethical responsibilities towards society.	

UNIT-I	
Introduction to Indian Constitution: The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian Constitution, The Making of the Constitution, The role of the Constituent Assembly – Preamble and Salient features of the Constitution of India. Fundamental Rights and its Restriction and Limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and Significance in Nation Building.	3 Hrs
UNIT-II	
Union Executive and State Executive: Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Special Provisions (Article 370, 371, 371J) for some States.	3 Hrs
UNIT-III	
Elections, Amendments and Emergency Provisions: Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44,61,73,74,75,86, and 91,94,95,100,101,118 and some important Case Studies. Recent Amendments with explanation. Important Judgements with Explanation and its impact on society (from the list of Supreme Court Judgements). Emergency Provisions, types of Emergencies and it's consequences. **Constitutional Special Provisions:** Special Constitutional Provisions for SC & ST, OBC, Special Provision for	3 Hrs

Women, Children & Backward Classes.	
UNIT-IV	
Professional / Engineering Ethics: Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India) : Profession, Professionalism, Professional Responsibility. Clash of Ethics, Conflicts of Interest. Responsibilities in Engineering - Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering.	3 Hrs
UNIT-V	
Internet Laws, Cyber Crimes and Cyber Laws: Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship, Cybercrimes and enforcement agencies.	3 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Have constitutional knowledge and legal literacy
CO2	Understand Engineering and Professional ethics and responsibilities of Engineers.
CO3	Understand the cyber crimes and cyber laws for cyber safety measure.

Reference Books	
1.	Constitution of India and Professional Ethics, T.S. Anupama, Sunstar Publisher
2.	Durga Das Basu (DD Basu): "Introduction to the Constitution on India", (Students Edition.) Prentice –Hall EEE, 19th/20th Edn., (Latest Edition) or 2008.
3.	Shubham Singles, Charles E. Haries, and Et al : "Constitution of India and Professional Ethics" by Cengage Learning India Private Limited, Latest Edition – 2018.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	--	--	--	--	--	--	--	--	--	--	--	--
CO2	2	--	--	--	--	--	--	3	--	--	--	--
CO3	--	--	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Semester: IV		
AEC4: SOFTWARE TOOLS FOR CHEMICAL ENGINEERS (Theory and Practice)		
Course Code: MVJ21CH47		CIE Marks:50+50
Credits: L:T:P: 1:0:2		SEE Marks: 50 +50
Hours:10 L+ 20 P		SEE Duration: 03+03 Hours

Course Learning Objectives: The students will be able to	
1	Understand the basic concepts of different software used for the various chemical processes.
2	Get insight into the design software practiced.
3	Assess different engineering problems using the relevant software.
4	Understand the plant layout and equipment used in the processes.

UNIT-I	
General introduction to process engineering design software (HYSYS and PRO II); computations using Microsoft excel; computer-aided design & drafting, piping and equipment design software.	2 Hrs
UNIT-II	
Process Simulation software- Introduction to Aspen HYSYS, Aspen PLUS, CHEMCAD.	2 Hrs
UNIT-III	
General Mathematical Modelling: introduction to MATLAB Simulink.	2 Hrs
UNIT-IV	
Computational Fluid Dynamics: introduction to COMSOL Multiphysics, ANSYS Fluent.	2 Hrs
UNIT-V	
Statistical software: introduction to Design of Experiments (DOE), Six Sigma Tools, Artificial Neural Networks (ANN).	2 Hrs

LABORATORY EXPERIMENTS

1. Data export from MS Excel to MAT LAB.
2. A typical shortcut approach for the initial conceptual estimation of the operation of binary distillation columns.
3. Modelling of Heat Exchanger using MAT LAB.
4. Determination of sixe of Heat Exchanger using CC-THERM (CHEMCAD).
5. Simulation of Steady state conditions problems using DWSIM software.
6. Simulation of Steady state –Vapor-Liquid conditions problems using DWSIM software.
7. Simulation of Steady state –Vapor-Liquid-Liquid conditions problems using DWSIM software.
8. Simulation of Steady state Solid-Liquid-Liquid conditions problems using DWSIM software.
9. Simulation of Steady state aqueous Electrolyte numerical problems using DWSIM software.

10. Performance of Internal combustion Engines using CFD software. 11. Determination of Pressure drops of a pump using ASPEN HYSYS. 12. Determination of Mass Balance Using ASPEN HYSYS.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the basic processes of engineering design software.
CO2	Get an insight of mathematical modeling practiced using MATLAB software.
CO3	Outline the process simulation software.
CO4	Explain the computational fluid dynamics with various software.
CO5	Learn the statistical software for the design of experiments.

Reference Books	
1.	Introduction to Software for Chemical Engineers, Mariano Martin, 2019, 2nd edition, CRC Press.
2.	Chemical Process Engineering Volume 2: Design, Analysis, Simulation, Integration, and Problem Solving with Microsoft Excel-UniSim Software for Chemical Engineers, Heat Transfer and Integration, Process Safety, and Chemical Kinetics, Kayode A.C., Rahmat S-G, 2022, John Wiley and Sons.
3.	ASPEN PLUS® Chemical Engineering Applications, Al-Malah, K.I.M, 2016, Wiley.
4.	Fortan Programs for Chemical Process Design, Analysis, and Simulation, Kayode Coker 1995, Gulf Professional Publishing.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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

High-3, Medium-2, Low-1

Semester: IV

ADDITIONAL MATHEMATICS-II (Common to all branches)		
Course Code: MVJ21MATDIP-II		CIE Marks:50
Credits: L:T:P: 1:2:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	To familiarize the important concepts of linear algebra.
2	Aims to provide essential concepts differential calculus, beta and gamma functions.
3	Introductory concepts of three-dimensional geometry along with methods to solve them.
4	Linear differential equations.
5	Formation of partial differential equations.

UNIT-I	
Linear Algebra: Introduction - Rank of matrix by elementary row operations - Echelon form. Consistency of system of linear equations - Gauss elimination method. Eigen values and eigen vectors of a square matrix. Diagonalization of a square matrix of order two. **Self study**: Application of Cayley-Hamilton theorem (without proof) to compute the inverse of a matrix-Examples.	8 Hrs
UNIT-II	
Differential calculus: Indeterminate forms: L-Hospital rule (without proof), Total derivatives, and Composite functions. Maxima and minima for a function of two variables. **Beta and Gamma functions:** Beta and Gamma functions, Relation between Beta and Gamma function-simple problems. **Self study**: Curve tracing.	8 Hrs
UNIT-III	
Analytical solid geometry : Introduction –Directional cosine and Directional ratio of a line, Equation of line in space- different forms, Angle between two line, shortest distance between two line, plane and equation of plane in different forms and problems. **Self study**: Volume tetrahedron.	8 Hrs
UNIT-IV	
Differential Equations of higher order: Linear differential equations of second and higher order equations with constant coefficients. Inverse Differential operator, Operators methods for finding particular integrals , and Euler –Cauchy equation. **Self study**: Method of variation of parameters	8 Hrs
UNIT-V	
Partial differential equation: Introduction- Classification of partial differential equations, formation of partial differential equations.	8 Hrs

Method of elimination of arbitrary constants and functions. Solutions of non-homogeneous partial differential equations by direct integration. Solution of Lagrange's linear PDE. **Self study:** One dimensional heat and wave equations and solutions by the method of separable of variable	

Course Outcomes: After completing the course, the students will be able to	
CO1	Make use of matrix theory for solving system of linear equations and compute eigenvalues and eigen vectors required for matrix diagonalization process.
CO2	Learn the notion of partial differentiation to calculate rates of change of multivariate functions and solve problems related to composite functions and Jacobians.
CO3	Understand the Three-Dimensional geometry basic, Equation of line in space- different forms, Angle between two line and studying the shortest distance .
CO4	Demonstrate various physical models through higher order differential equations and solve such linear ordinary differential equations.
CO5	Construct a variety of partial differential equations and solution by exact methods.

Reference Books	
1.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43rd Edition, 2013, .
2.	G. B. Gururajachar, Calculus and Linear Algebra, Academic Excellent Serie Publication, 2018-19
3.	Chandrashekar K. S, Engineering Mathematics-I, Sudha Publications, 2010.

Continuous Internal Evaluation (CIE):
Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):
Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to

answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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CO3	3	3	--	3	--	--	--	--	--	--	--	1
CO4	2	2	--	3	--	--	--	--	--	--	1	1
CO5	2	2	--	2	--	--	--	--	--	--	--	1