Semester: VI		
TRANSPORT PHENOMENA (Theory)		
Course Code: MVJ21CH61		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	To introduce the students about basic laws of momentum, heat and mass transfer.
2	To determine the heat transfer rate and temperature distribution for different heat transfer situations.
3	To determine the mass transfer rate and concentration distribution for different mass transfer situations.
4	To study the different analogies between mass, momentum and mass transfer.
5	To study the different transport process analogies of the fluid.

UNIT-I	
Introduction: Momentum energy and mass transport newton's law of viscosity. Newtonian and non-newtonian fluids. Fourier's law of heat conduction, fick's law of diffusion, effect of temperature and pressure on transport properties of fluids. numerical problems on the application and use of NLV, FLHC and FLD.	10 Hrs
UNIT-II	
Velocity Distribution in Laminar Flow: Different flow situations, steady state shell momentum balances, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through a circular tube, flow through annulus. steady state. shell energy balances: general boundary conditions applicable to energy transport problems of chemical engineering. heat conduction through compound walls. overall heat transfer coefficient.	10 Hrs
UNIT-III	
Temperature Distribution in Solids and in Laminar Flow: Different situations of heat transfer: heat conduction with internal generation by electrical and nuclear energy sources, heat conduction in a cooling fin: forced and free convection heat transfer. concentration Distributions in laminar flow: Steady state shell mass balances. general boundary conditions applicable to mass transport problems of chemical engineering. equimolar counter diffusion. numerical problems.	10 Hrs
UNIT-IV	
Concentration Distributions in Laminar Flow: Diffusion through stagnant gas and liquid films, diffusion with homogeneous reaction, diffusion with heterogeneous reaction-diffusion into falling film – forced convection mass transfer. numerical problems.	10 Hrs

UNIT-V	
Analogies between Momentum, Heat and Mass Transport: Analogies between momentum, heat and mass transport - Reynolds, Prandtl and Chilton & Colburn analogies. equations of change: equation of continuity, equation of motion; Navier – stokes equation. macroscopic balance for isothermal systems (mass, momentum, and mechanical energy balance).	10 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the basic transport equations for momentum, heat & mass transfer.
CO2	Develop the mathematical model to develop flux equations for steady state momentum and energy transfer in various situations.
CO3	Develop mathematical models to determine transfer fluxes and temperature, concentration distribution for heat sources and systems involving diffusion.
CO4	Develop the flux equations for steady state mass transfer in various situations.
CO5	Apply equation of change in solving steady state problems & analyse analogies between momentum, heat and mass transport.

Reference Books	
1.	Transport phenomena, Bird, R. B., Stewart, W. E., & Lightfoot, E. N., Second Edition, 2006, John Wiley & Sons, ISBN: 9752843670
2.	Transport phenomena, B. M Suryavashi and L. R Dongre, Seventh Edition, 2013, Nirali Prakashann India, ISBN: 9381962561
3.	Transport phenomena, Brodkey, R. S., & Hershey, H. C., First Edition, 2003, Brodkey publishing, ISBN: 0972663592
4.	Transport Phenomena, J. W. Van Heuven, W. J. Beek, K. M. K. Muttzall, Second Edition, 1999, Wiley, ISBN: 0471999903

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	3	2	--	--	--	--	--	--	--	--	--	--
CO2	3	3	--	--	--	--	--	--	--	--	--	--
CO3	3	3	3	3	--	--	--	--	--	--	--	--
CO4	3	3	--	--	--	--	--	--	--	--	--	--
CO5	3	3	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Semester: VI		
CHEMICAL PROCESS EQUIPMENT DESIGN & DRAWING (Theory and Practice)		
Course Code: MVJ21CH62		CIE Marks:50+50
Credits: L:T:P: 2:2:2		SEE Marks: 50 +50
Hours:40 L+26P		SEE Duration: 03+03 Hours

Course Learning Objectives: The students will be able to	
1	To study various phases in process design & development.
2	To determine cost involved in various processes.
3	Estimation of capital cost, alternative investments and replacement analysis.
4	Understand the chemical engineering principles applicable for designing chemical engineering equipment
5	To study how to calculate about profitability, depreciation& taxes.

UNIT-I	
Introduction: chemical engineering plant design, general overall design considerations, cost estimation; factors effecting profitability of investments. optimum design: optimum economic design, optimum operating design, the design approach Process Design Development: design project procedure; types of designs, design information from the literature.	8 Hrs
UNIT-II	
Equipment design and Specification: factors in equipment scale up and design, safety factors, materials of constructions, health and safety hazards; sources of exposure, exposure evaluation, safety regulation.	8 Hrs
UNIT-III	
Material Transfer, handling and treatment equipment -design and costs. Heat transfer equipment design and costs. Mass transfer equipment design and costs.	8 Hrs
UNIT-IV	
Cost analysis: Elements of project cost - cost information, Factors affecting investment & production cost, Estimation of capital investment, operation costs, project financing, Factors in capital investment, Estimation of working capital, cost index, taxes and insurance. Time value of money: Types of interests, Effective and nominal interest rates, present worth and discount.	8 Hrs
UNIT-V	
Depreciation & taxes: Types of Depreciation and calculation methods Profitability: Profitability, Cash flow diagrams, break even analysis, measures of process profitability, methods of evaluation of profitability - Rate of return on investment, Discounted cash flow based on full-life	8 Hrs

performance, Net present worth, Capitalized costs, Payout period, Simplified model for economic analysis of process design.	

LABORATORY EXPERIMENTS

1. Sectional views: Representation of the sectional planes
2. Sectional views: Sectional lines and hatching
3. Sectional views: Selection of section planes
4. Sectional views: Types of sectional views
5. Proportionate drawings: Equipment and piping symbols
6. Vessels components: Vessel openings
7. Vessels components: Manholes
8. Vessels components: Vessel enclosures
9. Vessels components: Vessel support
10. Vessels components: Jackets, Shell and tube heat exchanger.
11. Reaction vessel with the help of solid edge software and different types of Evaporators.
12. P & I Diagrams.
13. Assembly drawings: Joints: Cotter joint with sleeve
14. Assembly drawings: Joints: Socket and Spigot joint
15. Assembly drawings: Joints: Flanged pipe joint
16. Assembly drawings: Joints: Union joint
17. Assembly drawings: Joints: Stuffing box and Expansion joint (Screw type or flanged type).

Any 12 experiments to be conducted

Course Outcomes: After completing the course, the students will be able to	
CO1	Develop an understanding for the general designs considerations.
CO2	Understanding of materials cost and handling.
CO3	Evaluation of costs and assets and insurances.
CO4	Apply chemical engineering principles to design chemical process equipment applicable for heat and mass transfer operations.
CO5	Understand design procedure of chemical process equipment.

Reference Books	
1.	The Chemical Process Industries Infrastructure: Function and Economics, James Riley Couper, First Edition, 2000, CRC Press USA, ISBN:9788123910826
2.	Plant design and economics for chemical engineers, Peters, M. S., Timmerhaus, K. D., & West, R. E, Fifth Edition, 2003, New York: McGraw-Hill, ISBN: 9780072392661
3.	Unit Operations in Chemical Engineering, Warren L. McCabe & Julian C. Smith & Peter Harriott, Seventh Edition, 2017, India: McGraw Hill Education, ISBN:9339213238
4.	Chemical process economics, Happel, J. and Jordan, D.J. FirstEdition, 2005, New Yark: Marcal Dekker Inc., ISBN:0824761553

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 for10 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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	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: VI		
MASS TRANSFER – II (Theory and Practice)		
Course Code: MVJ21CH63		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	Be able to understand different separation techniques.
2	Acquire the knowledge of separation processes like distillation, adsorption, and extraction.
3	Be able to use the phase equilibrium concepts in mass transfer related problems.
4	Be able to design staged /packed column for mass transfer operations.
5	Be able to design distillation column, absorber and calculations involved in liquid-liquid extraction.

UNIT-I	
Gas Liquid Contacting Systems: Types, construction and working of plate and packed columns, types and properties of industrial packing's, plate efficiencies, HETP and HTU concepts. Absorption: Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption columns. Design of Plate columns. Absorption and desorption factors.	8 Hrs
UNIT-II	
Packed Tower Absorption: Liquid phase hold up and pressure drop in absorption towers. Design of packed towers (process design-height and diameter). Multi-component absorption. Absorption with chemical reaction. Distillation: Introduction. Vapour liquid equilibria (T-x,y, P-x,y. H-x,y and x-y diagrams for binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component systems. Non-ideal systems. Azeotropes. Immiscible systems. Atmospheric distillation, Flash and simple distillation, Distillation in a packed tower.	8 Hrs
UNIT-III	
Distillation (Contd.): Multi-stage rectification column. Design using McCabe Thiele and Lewis-Sorel methods for binary mixtures. Distillation (Contd.): Ponchon- Savarit method. Introduction to Multi component distillation, Vacuum, molecular, extractive and azeotropic distillations.	8 Hrs
UNIT-IV	
Liquid-Liquid Extraction: Ternary equilibrium. Solvent selection. Single	8 Hrs

stage and multi-stage cross-current, counter-current extraction. Equipment for liquid-liquid extraction, fractional extraction.	
UNIT-V	
Leaching Operation: Equipment for leaching. Preparation of solids for leaching. Equilibrium diagrams. Calculation of single stage and multi-stage leaching operation.	8 Hrs
LABORATORY EXPERIMENTS	
1. Determination of diffusivity 2. Verification of Rayleigh's equation by conducting simple distillation 3. Determination of HETP using packed column distillation 4. Study the characterization of steam distillation 5. Solid – liquid leaching: Single stage and three stage cross current 6. Verification of Himus equation 7. Study the drying characteristics in a tray dryer 8. Adsorption studies: single stage and two stage cross-current operation 9. Determination of Vapour Liquid Equilibrium (VLE)data 10. Liquid extraction: single stage and three stage cross current operation 11. Hold up studies in packed columns 12. Study the drying characteristics in a vacuum dryer 13. Determination of mass transfer coefficient by conducting wetted wall column experiment 14. Measurement of cooling tower characteristic parameter 15. Solid dissolution Studies 16. Separation of DNA using Gel-electrophoresis experiment 17. Casting of membrane **Any 12 experiments to be conducted**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the concepts of HETP, NTU and HTU to design various gas-liquid contacting systems.
CO2	Apply the concept of absorption to calculate the number of plates and height of continuous absorber.
CO3	Estimate the composition of distillate and residue using VLE data and explain the different distillation processes.
CO4	Apply McCabe Thiele, Ponchon - Savarit method and Lewis-Sorel methods for multi component mixtures to calculate no of trays in multi-stage rectification column.
CO5	Develop equations for the material balance for stage wise operations in liquid-liquid extraction and leaching operations and working of the equipment.

Reference Books	
1.	Mass transfer operations, Treybal, R. E.,Third Edition, 2017, New York: McGraw Hill Education,ISBN:1259029158

2.	Unit Operations in Chemical Engineering, McCabe & Smith, Seventh Edition, 2017, New York: McGraw Hill Education,ISBN:9339213238
3.	Principles of unit operations, Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., & Andersen, L. B., Second Edition, 2008, John Wiley & Sons.ISBN:9788126518296
4.	Chemical Engineering, Coulson and Richardson, Third Edition, 1999, Pergamon Press., ISBN:0750641428

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

CO5	3	3	1	3	1	-	-	-	-	-	-	-

High-3, Medium-2, Low-1

Semester: VI		
INDUSTRIAL POLLUTION AND CONTROL (Theory)		
Course Code: MVJ21CH641		CIE Marks:50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L+26T		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	To enhance knowledge and skills in the areas of importance of pollution, analysis & treatment of wastewater, polluted air, solid waste, noise and its control.
2	To inculcate awareness on environmental, societal, ethical, health and safety issues and their relevance in engineering.
3	To understand different types of pollutions.
4	To encourage for optimal resource utilization and sustainable lifestyles.
5	To promote environmental design.

UNIT-I	
Introduction: Importance of environment for mankind. Types of pollution. Damages from environmental pollution. Need of environmental legislations and environmental Acts in India. Environmental Impact Assessment and Challenges. Functions of central and state pollution control boards. Sampling and Analysis of Wastewater: Evaluation, classification and characterization of wastewater. Physical and chemical characteristics. BOD, COD and their importance. Types of water pollutants and their effects.	8 Hrs
UNIT-II	
Wastewater Treatment: Preliminary, primary, secondary, and tertiary treatments of wastewater. Advanced wastewater treatment. Recovery of materials from process effluents. Applications to Industries: Norms and standards of treated water. Origin, characteristics, and treatment methods in typical industries – petroleum refinery, pulp and paper, distillery, and textile processing.	8 Hrs
UNIT-III	
Air Pollution: Nature of air pollution. Classification of air pollutants. Sources of air pollutants. Air quality criteria and standards. Plume behavior and dispersion of air pollutants. Sampling of pollutants. Methods of estimation of air pollutants.	8 Hrs
UNIT-IV	
Air Pollution Control: Control methods for particulates and gaseous pollutants. Air pollution control methods and equipment. Source collection methods: raw material changes, process changes, and equipment modification. Air pollution Control equipment. Origin, control methods, and equipment used in typical industries- metallurgical	8 Hrs

industries, and cement industries.	
UNIT-V	
Solid Waste Management: Origin, classification and microbiology. Engineered systems for solid waste management – generation, onsite handling, storage, collection, transfer and transport, composting, sanitary land filling. Noise Pollution: Generation of noise, control strategies in industries. Recent trends in industrial waste management, cradle to grave concept, lifecycle analysis, clean technologies.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Discuss the fundamentals of environmental pollution and the associated legal aspects.
CO2	Explain various wastewater treatment methods and the origin, characteristics, and treatment methods in typical industries.
CO3	Interpret the aspects of air pollution and the methods of estimating various air pollutants.
CO4	Outline the control strategies for industrial air pollution control to be within the ambit of environmental regulations.
CO5	Explain different techniques for municipal solid waste management, noise pollution and the recent trends in industrial waste management.

Reference Books	
1.	Environmental Pollution Control Engineering, C.S. Rao, second Edition (Reprint), 2015, New Age International, ISBN: 978-81-224-1835-4.
2.	Waste Water Engineering Treatment Disposal Reuse, Metcalf and Eddy, fourth Edition, 2003, Tata McGraw Hill, ISBN: 978-0071241403.
3.	Pollution Control in Process Industries, S.P. Mahajan, 27th Edition, 2012, Tata McGraw Hill, ISBN: 9780074517727.
4.	Principles and practices of air pollution control and analysis, Mudakavi, J. R. first Edition, 2010. IK International Pvt Ltd. ISBN: 9789380026381

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	3	3	--	--	2	--
CO2	3	3	--	--	1	3	3	3	--	--	2	--
CO3	3	3	--	--	--	3	3	3	--	--	2	--
CO4	3	3	--	--	1	3	3	3	--	--	2	--
CO5	3	3	--	--	1	2	2	2	--	--	2	--

High-3, Medium-2, Low-1

Semester: VI		
NANOSCIENCE & NANOTECHNOLOGY (Theory)		
Course Code: MVJ21CH642		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 behavior of various smart materials and its applications.	
2	Understand basics and synthesis of nano materials and their properties.	
3	Learn to analyze and assess parameters involved in synthesis and characterization.	
4	Understand the synthesis techniques at nanoscale.	
5	Understand the applications of nano technology in various fields.	

UNIT-I	
Introduction and scope - Introduction to nanoscale, history, evolution of various disciplines towards nanoscale potential applications, recent achievements in nanotechnology, short-term commercial nanotechnology products, specific applications, challenges and opportunities, technology scope, areas and sub disciplines, commercialization scope, present course of investigation.	8 Hrs
UNIT-II	
Basic nanotechnology science: Introduction, approach & scope, sub atomic particles, basic entities/particles of interest, basic physics terms of interest, scale of atomic entities, atomic distances, elementary and non-elementary particles, key physical properties of elements, basic properties of silicon and basics of transistor operations: transistor, manufacturing approaches, manufacturing limitations.	8 Hrs
UNIT-III	
Nanomaterials: Synthesis and Characterization: Introduction, basic nanostructures: CNTs, nanowires, nanocones; quantum dots, quantum dot nanocrystals, ultra-nanocrystalline diamond, nanocomposites, thin films, nanofoams, nanoclusters, smart nanostructures. Characterization of Nano materials: Microscopy-Scanning tunnelling microscope, atomic force microscope, scanning electron microscopy, Field Emission Scanning Electron Microscopy (FESEM), Transmission Electron Microscopy (TEM), Environmental Scanning Electron Microscopy (ESEM) High Resolution Transmission Electron Microscope (HRTEM), Surface enhanced Raman Spectroscopy, X-ray diffraction technique, X ray Photoelectron Spectroscopy Surface area analysis, particle size analysis, gravimetric analysis.	8 Hrs
UNIT-IV	
Nanoscale Manufacturing: Nano manipulation, Nanolithography-Optical lithography, Photolithography, Dip pen nanolithography,	8 Hrs

Extreme UV Lithography, Electron beam (e-beam) lithography, Epitaxial Growth: classical growth modes, techniques for epitaxy: Liquid Phase Epitaxy (LPE), Physical Vapor Deposition (PVD), Molecular Beam Epitaxy (MBE). Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), Self-Assembly.	
UNIT-V	
Application of Nanotechnology: Environment: remediation and mitigation using metal oxide nano particles, magnetic particles, Nanomembranes and nanofilters, Pollution prevention: nanocatalysis, environmental sensors Medicine and healthcare: diagnosis, biosensors, drug delivery, therapy Energy: Solar energy- Photovoltaics, Dye-sensitised solar cell, Quantum-dot- sensitized solar cells. Hydrogen energy-Hydrogen production and Hydrogen storage, hydrogen fuel cell, Energy Savings-Insulators and smart coatings, Energy- harvesting materials, Information and communication technologies: Integrated circuits, Data storage, Photonics, Displays, Information storage devices, Wireless sensing and communication.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the concept of nano and its opportunities in various fields
CO2	Understand the basic science of basic nano technology
CO3	Identify various nano materials and recall nano materials synthesis, characterization techniques
CO4	Identify various nano manufacturing techniques.
CO5	Understand the applications of Nano technology in various fields.

Reference Books	
1	A textbook of nanoscience and nanotechnology, Varghese, P. I., & Pradeep, T., 2003, Tata McGraw-Hill Education.
2	Nanotechnologies: principles, applications, implications and hands-on activities: A compendium for educators, Fiiipponi, L., & Sutherland, D., 2012, European Union, Directorate General for Research and Innovation.
3	Nano Materials, Bandyopadhyay. K., 2007, First edition, New Age International Publishers.
4	An introduction: material science and engineering, Callister, W. D., 2007, John Wiley and Sons Inc.

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

High-3, Medium-2, Low-1

Semester: VI			
RENEWABLE ENERGY: RESOURCES AND TECHNOLOGIES (Theory)			
Course Code: MVJ21CH643			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	Study the technologies for harvesting renewable technology.		
2	Study photovoltaic's, wind power, hydropower, biomass energy, solar thermal power.		
3	Know about comparison of characteristics and cost of renewable.		
4	Understand energy audits and residential energy audits.		
5.	Understand the developing technology.		

UNIT-I	
Current Practices and Future Sustainability: Introduction to renewable energy: fundamentals and its impact on society and the environment, advantages and disadvantages of renewable energy sources, energy conservation and audits, zero waste technology, waste to wealth, sustainability, sources of renewables, comparison of characteristics and cost of renewables. Cleaner Production: Technologies for the clean energy production from the renewable materials.	8 Hrs
UNIT-II	
Photovoltaics, Solar thermal power, Solar Radiation, and Its Measurement: Solar constant, solar radiation at the earth's surface, solar radiation geometry, solar radiation measurements, applications of solar energy, solar water heating, space-heating (or solar heating of buildings), space cooling (or solar cooling of a building), solar thermal electric conversion, agriculture and industrial process heat, solar distillation, solar pumping, solar cooking. Geothermal energy, resource identification and development, geothermal power generation systems, geothermal power plants, case studies.	8 Hrs
UNIT-III	
Energy from biomass (bioenergy): Introduction, biomass conversion technologies, wet processes, dry processes, biogas generation, factors affecting bio-digestion, types of biogas plants (KVIC model & Janata model), selection of site for biogas plant. Bioenergy (thermal conversion): Methods for obtaining energy from biomass, thermal gasification of biomass, classification of biomass gasifiers, chemistry of the gasification process, applications of the gasifiers.	8 Hrs
UNIT-IV	

Wind energy: Introduction, basic components of WECS (wind energy conversion system), classification of WEC systems, types of wind machines (wind energy collectors), horizontal-axial machines and vertical axis machines. OTEC-Introduction, ocean thermal electric conversion (OTEC), methods of ocean thermal electric power generation, open and closed cycle OTEC system. Hybrid cycle energy from tides: Basic principles of tidal power, components of tidal power plants, operation methods of utilization of tidal energy, advantages and limitations of tidal power generation.	8 Hrs
UNIT-V	
Hydrogen as a Fuel: Introduction, methods of hydrogen production (principles only), storage, transportation, utilization of hydrogen gas, hydrogen as alternative fuel for motor vehicle, safety and management. Hydrogen technology development in India.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Developed concept about the various forms of energy
CO2	Comprehend about the principles of various forms of renewable energy
CO3	Apply the concept of zero waste, atom economy for waste management
CO4	Hands on learning to produce hydrogen from the feedstock.
CO5	Explains the various methods for hydrogen production, storage and transportation.

Textbooks:	
1	Non-conventional energy resources,.Rai, G. D., 2004, Khpu Khanna, India, 369, 331-337.
2	Renewable energy resources, Twidell, J., & Weir, T., 2015, Routledge.
3	Renewable energy: power for a sustainable future, Boyle, G., 1996, Oxford University Press.
4	Energy systems and sustainability: power for a sustainable future, Everett, R., Boyle, G., Peake, S., & Ramage, J., 2012, Oxford University Press.

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	2	1	--	1	--	1
CO2	2	1	--	--	--	1	2	--	--	--	--	1
CO3	1	2	1	2	1	3	3	3	2	1	1	--
CO4	2	1	2	2	--	--	2	--	--	1	3	--
CO5	2	1	--	--	--	1	2	--	--	--	--	1

High-3, Medium-2, Low-1

Semester: VI		
FOOD TECHNOLOGY (Theory)		
Course Code: MVJ21CH644		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	Impart knowledge to the students about food processing and various unit operations.
2	Understand the knowledge of formation of foods.
3	Understand the concepts of enzymatic reactions.
4	Gain knowledge on the preservatives and additives.
5	Know the importance of the food safety.

UNIT-I	
Introduction and Quality Attributes of Food: Function of foods. Food in relation to health. Aim of food science and technology. Quality attributes – Appearance factors, Textural factors, Flavor factors. Visual and objectively measurable attributes. Aroma of foods – introductory ideas, formation, chemistry and analysis. Taste – introductory ideas, formation and chemistry. Additional quality; quality standards, quality control. Introduction to sensory evaluation of foods and beverages. Modern Trends In Food Science: Biotechnology in food. Biofortification, Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition labeling. Careers in food science and food industries.	8 Hrs
UNIT-II	
Formation and Chemistry of Food: Carbohydrates. Proteins. Lipids. Vitamins. Minerals. Water. Biotin. Choline. Phytochemicals. Food Processing and Preservation: Food deterioration – Causes. Aims and objectives of preservation and processing. Unit operations in processing. Different methods of food preservation – low temperature, high temperature, preservatives, osmotic pressure, dehydrations. food irradiation; processing and preservations of milk and dairy, vegetables and fruits, cereals, legumes and nuts, meat and meat products, fats and oils, beverages, sugars, sweeteners, honey and confectionary, salt and spices.	8 Hrs
UNIT-III	
Enzymatic and Non-Enzymatic Reactions During Storages: Introduction to enzymes. Nature and function of enzymes. Classification of enzymes. Hydrolases – Esterases, amylases, pectic enzymes. Proteases. Oxidoreductases – phenolases, glucose oxidase, catalase, peroxidase, lipoxygenase, xanthine oxidase. Immobilized enzymes. Uses and suggested uses of enzyme in food processing. Non-enzymatic	8 Hrs

reactions.	
UNIT-IV	
Food Additives: Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-choking agents, leavening agents, nutrient supplements, non- nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety. Food Contamination and Adulteration: Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards.	
UNIT-V	
Environmental Concerns and Food Safety: Water in food production. Properties and requirements of processing water. Environmental concerns – solid waste disposal, wastewater properties, wastewater treatment. Safety hazards and risks. Food related hazards. Processing and handling. Cleaning and sanitizing.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the quality attributes and chemistry of foods
CO2	Apply principles of packaging, storing and preservation, food poisoning, food related hazards and safety
CO3	Explain the various causes of food deterioration and food poisoning.
CO4	Identify appropriate processing, preservation, and packaging method.
CO5	Analyze product quality and effect of processing technique on it.

Reference Books	
1	Food Science, B. Srilakshmi, 2007, 4th edn, New Age International.
2	Foods: Facts and Principles, N. Shakuntala Manay and M. Shadaksharamurthy, 2005, New Age Publishers.
3	Introduction to Food Science, Rick Parker, 2001, Thomsan Detmer.
4	Food Processing and Preservation, G. Subbulakshmi and Shobha A. Udupi, 2001, New Age International.

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	3	3	3	--	3	--	--	--	--	--	--	--
CO2	3	3	3	--	3	--	--	--	--	--	--	1
CO3	3	3	3	--	3	--	--	--	--	--	--	2
CO4	3	3	3	--	3	--	--	--	--	--	--	2
CO5	3	3	3	--	3	--	--	--	--	--	--	2

High-3, Medium-2, Low-1

Semester: VI		
AEC6: DATA ANALYTICS FOR CHEMICAL ENGINEERS (Theory)		
Course Code: MVJ21CH66		CIE Marks:50
Credits: L:T:P: 1:0:0		SEE Marks: 50
Hours: 20L		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	Process the big experimental data set for the analysis and finding of specific goal and solution.
2	Understand about statistical analysis and technologies on data to find trends and solve problems.
3	Understand about building a business strategy or ensuring the safety and efficiency of an engineering project.
4	To Learn about the Internet of Things uses and applications.
5	To learn about the data management.

UNIT-I	
Introduction to data science, data analytics, big data, internet of things, relationship between data science and statistics, limitations and failures of data science, methodologies of data science in chemical engineering.	4 Hrs
UNIT-II	
Trends in Data science: Experimentation in data science, modelling and computation, machine learning, big data analytics, spreadsheet and data management, relational database management system (RDBM's).	4 Hrs
UNIT-III	
Data Science Engineering: Software and applications engineering, data warehousing, big data infrastructure and tools. Data Management and Governance: Data stewardship, curation and preservation	4 Hrs
UNIT-IV	
Research methods and project management for research related professions and business process management for business related professions, classification & clustering of data, time series, multivariate statistics, data visualization.	4 Hrs
UNIT-V	
Data science in computational molecular science and engineering, energy systems and management, case studies for optimization of production and rejuvenation of oil and gas assets.	4 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the basics of Data science, Big data, Data Analytics and statistics.
CO2	Recent trends in Data science, Relational Data base Management system (RDBM's)
CO3	Explains the Data Management and Governance, Preservation curve and

	curation.
CO4	Explains the Research Methods and the Process Management for business related Professionals.
CO5	Relational data science in the field of Computational Engineering & Biology.

Reference Books	
1.	Advanced data analysis and modelling in chemical engineering, Constales, D., Yablonsky, G., D'hooge, D. R., Thybaut, J. W., & Marin, G. B., First Edition, 2016, Elsevier, ISBN: 978-0444594853
2.	An introduction to statistical learning, James, G., Witten, D., Hastie, T., &Tibshirani, R., First Edition, 2013, New York: Springer, ISBN: 978-1461471370
3.	Introduction to data mining, Tan, P. N., Steinbach, M., & Kumar, V., First Edition, 2016, Pearson Education India, ISBN: 978-9332571402
4.	Data Mining: Concepts and Techniques, Jiawei Han, Micheline Kamber, Jian Pei, Third Edition, 2011, Morgan Kaufmann, ISBN: 978-9380931913

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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CO2	2	1	--	--	--	--	--	--	--	--	--	1
CO3	2	1	--	--	--	--	--	--	--	--	--	--
CO4	2	1	--	--	--	--	--	--	--	--	--	--
CO5	2	1	--	--	--	--	--	--	--	--	--	--

High-3, Medium-2, Low-1

Semester: VII		
CHEMICAL PROCESS MODELLING AND SIMULATION (Theory and Practice)		
Course Code: MVJ21CH71		CIE Marks:50+50
Credits: L:T:P: 2:2:2		SEE Marks: 50 +50
Hours:40 L+26P		SEE Duration: 03+03 Hours

Course Learning Objectives: The students will be able to	
1	Apply numerical techniques to solve chemical engineering problems.
2	Analyze chemical engineering system in term of modeling principle.
3	Develop simple chemical engineering models.
4	Develop algorithm for modelling & solve the model.
5	Distinguish simulation from design of equipment.

UNIT-I	
Modelling: Models and model building, principles of model formulations, precautions in model building, degree-of-freedom analysis, selection of design variables, review of numerical techniques, model simulation. Review of shell balance approach, continuity equation, energy equation, equation of motion and momentum, transport equation of state equilibrium and kinetics, thermodynamic correlations for the estimation of physical properties like phase equilibrium, bubble, and dew points.	8 Hrs
UNIT-II	
Basic formulation of mathematical modelling: Basic tank model – Level V/s time. **Models in separation process:** Batch Distillation – Vapour composition with time, Multistage distillation and multi-component flash drum, solvent extraction (steady & unsteady state), multistage gas absorption.	8 Hrs
UNIT-III	
Models in heat transfer operation: Heat conduction through cylindrical pipe (steady & unsteady state), cooling of tanks, and unsteady state heat transfer by conduction. **Models in fluid flow operation:** fluid through packed bed column, flow & film on the outside of a circular tube, laminar flow of Newtonian liquid in a pipe, gravity flow tank.	8 Hrs
UNIT-IV	
Models in reaction engineering: Chemical reaction with diffusion in a tubular reactor, gas phase pressurized CSTR, two phase CSTR, reactors in series (constant and variable hold-ups), batch reactor with mass transfer.	8 Hrs
UNIT-V	
Simulation of the models, tearing and flow sheeting, modular and equation-solving approach (elementary treatment only). Introduction and use of process simulation software (DWSIM/ASPEN PLUS/ ASPEN	8 Hrs

HYSYS) for flow sheet simulation.	

LABORATORY EXPERIMENTS

1. Introduction to suggested software available (flow sheeting)
2. Simulation of shell and tube heat exchanger.
3. Simulation of centrifugal pump/compressor.
4. Simulation of flash drum/separator.
5. Simulation of single stream gas heater/cooler.
6. Simulation of CSTR for liquid phase reaction.
7. Simulation of distillation column.
8. Mixing of ideal liquid streams.
9. Generation of VLE data of binary component system.
10. Determination of equilibrium conversion of reversible reactions.
11. Material balance on reactor based on yield/conversion data.
12. Process simulation study involving mixing, reactor, heat exchanger for the following.
13. Ethylene glycol from ethylene oxide.
14. Propylene glycol from propylene oxide.
15. Aromatic stripper with recycle stream (Benzene, Toluene, Xylene).
16. Styrene from ethyl benzene.
17. Process simulation study involving distillation for the atmospheric distillation of crude oil.

Any 12 experiments to be conducted

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the various equations to simple chemical engineering problems.
CO2	Develop the modelling equations for chemical engineering problems pertaining to mass transfer.
CO3	Strategies in developing mathematical models for momentum and heat transfer applications.
CO4	Applying the modelling concepts to the transport problems involving chemical reactions.
CO5	Simulate a process using process simulators (DWSIM/ASPEN Plus/ ASPEN Hysys).

Reference Books	
1.	"Process plant simulation", Babu, B. V. First edition, 2004, Oxford University Press, USA. ISBN: 9780195668056.
2.	"Process Modeling Simulation, and Control for Chemical Engineers", William, L., & William, L., Second Edition, 2003, McGraw-Hill Publishing Company.
3.	"Chemical engineering computation with MATLAB", Yeo, Y. K. First edition, 2017, CRC Press, ISBN: 9781315114880
4.	"Fundamentals and Modeling of separation processes: Absorption, distillation, evaporation", Holland, C.D., Fifth edition, 2012, Prentice-Hall, Englewood Cliffs,

	N.J. ISBN:9780133443905.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

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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 for10 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.

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

High-3, Medium -2, Low-1