Academic Program: UG

Academic Year 2021-22

Syllabus

III & IV Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution approved by AICTE & Affiliated to VTU, Belagavi)

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SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for III& IV semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2021-22 till further revision.

Principal

Chairman BoS & HoD

SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

Vision and Mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs)

1. **Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific outcomes (PSOs)

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for III Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC300	BS	Engineering Mathematics – III	3-0-0	3	50	100	3	-	-
18UCHC300	PC	Chemical Process Calculations	4-0-0	4	50	100	3		-
18UCHC301	PC	Technical Chemistry**	3-0-0	3	50	100	3	-	-
18UCHC302	PC	Fluid Mechanics	4-0-0	4	50	100	3	-	-
18UCHC303	PC	Particulate Technology	4-0-0	4	50	100	3	-	-
18UCHC304	PC	Chemical Engineering Drawing	2-0-2	3	50	100	3	-	-
18UCHL305	PC	Particulate Technology Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL306	PC	Technical Analysis Laboratory	0-0-3	1.5	50	-	-	50	3
Total			**20-0-8**	**24**	**400**	**600**		**100**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

** To be handled by the Chemistry department faculty

Scheme for IV Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC400	BS	Engineering Mathematics – IV	3-0-0	3	50	100	3	-	-
18UCHC400	PC	Process Heat Transfer	4-0-0	4	50	100	3	-	-
18UCHC401	PC	Chemical Reaction Engineering-I	4-0-0	4	50	100	3		
18UCHC402	PC	Chemical Engineering Thermodynamics	3-2-0	4	50	100	3	-	-
18UCHC403	PC	Pollution Control Engineering	3-0-0	3	50	100	3	-	-
18UCHC404	PC	Energy Technology and Management	3-0-0	3	50	100	3	-	-
18UCHL405	PC	Computational Methods & Simulation Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL406	PC	Fluid Mechanics Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL407	PC	Introductory Project	0-0-2	1	50	-	-	-	-
Total			**20-2-8**	**25**	**450**	**600**		**100**	

Total credits offered for the Second year: 49

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the Second year: 49

III Semester

18UMAC300	Engineering Mathematics-III	(3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLO):

1. To have an insight into Laplace transforms, Fourier series, Fourier transforms, Difference equations and Z-transforms. To develop the proficiency in variational calculus and solving ODE's arising in engineering applications, using numerical methods.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Transform the given function using Laplace/Fourier transforms depending on the nature of engineering applications.			1
CO-2	Express periodic function as a Fourier series and obtain the various harmonics of the Fourier series expansion for the given numerical data.			1,2
CO-3	Solve difference equations using Z-transform.			1
CO-4	Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.		1,2	
CO-5	Determine the externals of functional using calculus of variations and solve problems arising in engineering.			1,2

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	1.2	1.3	-	-	-	-	-	-		-	-	-

Pre-requisites: A basic course on differentiation and integration of function.
Contents:

Unit-I

Laplace Transforms: Definition and Properties. Laplace transform of elementary functions. Laplace transforms of Periodic functions and unit-step function problems. **Laplace Transforms**: Inverse Laplace transform - problems, Convolution theorem(without proof) to find the inverse Laplace transform and problems, solution of linear differential equations using Laplace transform. **08 Hrs.**

Unit-II

Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions of period 2® and arbitrary period. Half- range Fourier series. Practical harmonic analysis, examples from engineering field. **08 Hrs.**

Unit-III

Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Simpleproblems.
Z-Transforms and Difference Equations: Z-transform- definition, Standard Z-transforms, Damping and shifting rules, Initial value and Final value theorems (without proof) with problems. Inverse Z-transform.Simple problems.Difference equations-basic definition.Application of Z-transform to solve Difference equation. **08 Hrs.**

Unit-IV

Numerical Solutions of Ordinary Differential Equations (ODE's): Numerical solution of ODE's of first order and first degree-Taylor's series method, Modified Euler's method. Runge–Kutta method of fourth order, Milne's predictor and corrector method (Noderivations of formulae).Problems. **07 Hrs.**

Unit-V

Numerical Solution of Second Order ODE's: Runge-Kutta method and Milne's predictor and Corrector method. (No derivations of formulae).
Calculus of Variations: Variation of function and functional, variational problems, Euler's equation (without proof), Geodesics (plane), hanging chain problems. **08 Hrs**

Reference Books:

1) B.S. Grewal "Higher Engineering Mathematics", Khanna Publishers, 44/e, 2017.
2) E. Kreyszig "Advanced Engineering Mathematics", John Wiley & Sons, 10/e (Reprint), 2016.
3) Srimanta Pal et al., "Engineering Mathematics", Oxford University Press, 3/e, 2016.

18UCHC300	Chemical Process Calculations	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To study and understand the importance of stoichiometry, material and energy balances and applying these principles to industrial and theoretical problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12) /PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the fundamental and derived units with dimensions and calculate compositions of solutions.	1	2,3	13
CO-2	State ideal gas law and study humidification using psychrometric charts.	2,3	1	-
CO-3	Evaluate problems on steady state material balance without chemical reactions.	13	2,3	1
CO-4	Develop steady state material balance with chemical reaction and determine conversion, yield and selectivity.	13	2,3	1
CO-5	Compute ultimate and proximate analysis of fuels and perform calculations on energy balances.	2,3	1	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.8	2.4	2.4	-	-	-	-	-	-	-	-	-	2.0	-	-

Course content:

Unit-I

Units and Dimensions: Fundamental and derived units, Conversion of units, Dimensional consistency of equations. Dimensionless groups and constants.Conversion of equations.

Basic Chemical Calculations: Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases.Concept of normality, molarity, molality, ppm.

10 Hrs.

Unit-II

Vapour - Gas Concepts: Ideal gas law, vapour pressure concepts and calculation for miscible and immiscible systems. Real gases, Cubic equations of state. Humidification, drybulb and wet bulb temperature, molal humidity, saturation humidity and psychrometric charts. **09 Hrs.**

Unit-III

Material Balance Without Reaction: General material balance equation for steady and unsteady states. Typical steady state material balances in mixing, evaporation drying distillation, absorption, extraction and Crystallization. Material balances involving bypass, recycle and purging operations. **09 Hrs.**

Unit-IV

Steady State Material Balance with Reaction: Principles stoichiometry, limiting and excess reactants. Effect of inerts, fractional and percentage conversion.Yield and selectivity for multiple reactions. **12 Hrs.**

Unit-V

Fuels and Combustion: Ultimate and proximate analysis of fuels. Calculations involving burning of solid, liquid and gaseous fuels.Excess air, air to fuel ratio calculations.

Energy Balance: General steady state energy balance equation. Heat capacity, enthalpy, heat of formation reaction and combustion.Determination of heat of reaction at standard and elevated temperatures. **12 Hrs.**

Reference Books:

1) Hougen, O.A., Waston, K.M. and Ragatz, R.A., “Chemical Process Principles Part – I, Material and Energy Balances”, 2/e, CBS publishers and distributors, New Delhi, 1995.
2) Himmelblau, D.M., “Basic Principles and Calculations in Chemical Engineering”, 6/e, Prentice Hall Of India, New Delhi, 1997.
3) Bhatt, B.L. and Vora, S.M., “Stoichiometry”, SI Units, 3/e, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
4) K.V. Narayanama B. Lakshmikutty, “Stoichiometry and Process calculations” Prentice Hall India Limited, New Delhi, 2006. ISBN: 978-81-203-2992-8

18UCHC301	Technical Chemistry	(3-0-0) 3

Contact Hours: 39

Course Learning Objective(CLO):

1. The students are expected to learn the diffrent types of behaviour of inorganic materials, understand the aspects of inorganic polymers, reaction kinetics of coordinated compounds. Besides they are also expected to understand the basic aspects of nanotechnology and spectroscopy.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the electric, electronic and optical behavior of inorganic materials.	1	-	-
CO-2	Realize the basic knowledge of chemical kinetics	-	2	-
CO-3	Apply the knowledge of inorganic polymers and their applicability in material use, optimization and in various engineering applications.	1	-	-
CO-4	Comprehend the aspects of nanotechnology and its use for synthesis of engineering materials.	1	-	-
CO-5	Demonstrate the knowledge of different types and the mechanisms involved in spectroscopy and apply them in the analysis of organic compounds	-	1, 2	-

PO's/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.75	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisite: Engineering Chemistry

Course content:

Unit-I

Electronic, Electric and Optical Behaviour of Inorganic Materials: Metals, Insulators and Semiconductors, Electronic structure of solid, band theory, band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, the bandgap, synthesis and purification of semi conducting materials, single crystal growth, zone refining, fractional crystallization, semiconductor devices, rectifier transistors, photoconductors, photovoltaic cells, solar batteries. **08 Hrs.**

Unit-II

Inorganic Polymers: Introduction, preparation, properties and applications of Phosphorous-based polymers-polyphosphonitrilic chlorides and ultraphosphate glasses. Sulphur-based polymers-polymeric sulphur nitride and chalcogenide glasses.Silicon-based polymers-fluid polysiloxanes gums and silicone resins. **08 Hrs.**

Unit-III

Reaction Kinetics of Coordination Compounds: Introduction, electron transfer reactions: Outer-sphere reactions, ligand-bridged inner sphere reactions doubly bridged inner-sphere transfer, one electron and two electrons transfers, non-complementary reactions. Ligand exchange via electron exchange. Mechanisms of ligand substitution reactions-general considerations, substitution reactions of square planar and octahedral complexes. Base-catalyzed hydrolysis of cobalt (III) ammine complexes. **08 Hrs.**

Unit-IV

Introduction to Nano-Technology: Introduction to Nano scale, Nano materials, Synthesis of Nano particles by various methods: Spontaneous growth, Evaporation and condensation growth, Vapor-liquid solid growth, stress induced recrystalization. Physical vapour deposition (PVD): Evaporation molecular beam expitaxy (MBE), sputtering. Comparison of Evaporation and sputtering Chemical vapour deposition (CVD), Wet chemical synthesis methods: sol-gel, hydrothermal, co-precipitation and solution combustion methods. Unique properties of nanomaterials and their applications in Engineering field. **08 Hrs.**

Unit-V

Introduction to Spectroscopy: Study of chromatography, Paper, Thin layer and Gas chromatography and their applications. FTIR and UV-visible spectroscopy and their applications in analysis of organic compound. **07 Hrs.**

Reference Books:

1) J.D. Lee “Concise Inorganic Chemistry”,5/e, Wiley’s Publication,2012.
2) Wahid U. Malik; G.D. Tuli; R. D. Madan, “Selected Topics in Inorganic Chemistry”, Publisher: S Chand & Co Ltd, 2010,ISBN 10: 8121906008 .

3) The text book of physical chemistry Samuel GlasstoneMcmillan publications 1st Edition, 1974.
4) Fundamental of Analytical Chemistry D.A. Skoog, D.M. West, Holler and Saunders College Publishing, 8th Edition, 2005.
5) Er. RakeshRathi S, “Nanotechnology”, Chand & Company Ltd., Ram Nagar, New Delhi, 2010.

18UCHC302 Fluid Mechanics (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To introduce the concepts, principles, laws, observations and models of fluids at rest and in motion.
2. To provide the basis for understanding the fluid behavior, engineering design and control of fluid systems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the nature of fluids along with the properties and its measuring devices.	1	3	-
CO-2	Interpret and analyze the parameters of fluid flow and understand the mechanical energy equations	3, 13	2	1
CO-3	Derive and interpret the equations of fluid flow for liquids and also use dimensional analysis for solving problems	3, 5, 13	2	1
CO-4	Derive and interpret the equations of fluid flow for gases and also use dimensional analysis for solving problems	3, 5, 13	2	1
CO-5	Elucidate and characterize the different pipe fittings, pumps and flow measuring devices.	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	2.8	-	3.0	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Fluid Statics and Applications: Introduction to momentum transfer and unit operations. Nature of fluids, pressure and its measurements. Hydrostatic equilibrium, barometric equation, measurement of fluid pressure-manometers (U tube manometer, Inverted manometer, differential manometer), continuous gravity decanter, centrifugal decanter **11 Hrs.**

Unit-II

Fluid Flow Phenomena: Newtonian and Non-Newtonian fluids, types of flows, Shear rate, Shear stress, Rheological properties of fluids. Flow in boundary layer-Boundary layer separation and wake formation. Basic Equations of Fluid Flow: Macroscopic momentum balances, Mechanical energy equations. **10 Hrs.**

Unit-III

Incompressible Fluids: Laminar flow of incompressible fluids in pipes and conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy equation.Turbulent flow of incompressible fluids in pipes and conduits-Universal velocity distribution equation. Friction factor and Reynolds number relationship and friction factor chart. Nikuradse and Karman equation-Blasius equation, Prandtl one seventh power law. Changes in velocity or direction-Sudden expansion and contraction. **11 Hrs.**

Unit-IV

Compressible Fluids: Continuity equation, Mach number, total energy balance, velocity of sound, Ideal gas equation, adiabatic and isothermal flow equations, Flow through convergent-divergent sections, stagnation properties, velocity of sound or pressure wave in ideal gas equation. **Dimensional Analysis:** Dimensional homogeneity, Rayleigh's and Buckingham-Pi methods, dimensionless numbers, models and prototypes. **10 Hrs.**

Unit-V

Transportation and Metering of Fluids: Pipes, fittings and valves. Performance characteristics of Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors. Measurement of flowing fluids - full bore meters, area meter, insertion meters with flow rate equations. Flow through open channels- weirs and notches. Unsteady state flow- time taken to empty the liquid from the tank.

10 Hrs.

Reference Books

1) McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGraw Hill chemical engineering series. ISBN-10: 0072848235
2) Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1 and 2, 5/e. Butterworth publications. ISBN-10: 0750644451
3) Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4) R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 978813180294

18UCHC303	Particulate Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To study the basic principles of unit operations and its applications in process industries.

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12) PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply the principles of particle size analysis and unit operations to solve industrial screening problems.	1,2	13	3
CO-2	Classify size reduction equipments and evaluate their performance using laws of size reduction.	1,2	13	3
CO-3	Analyze pressure drop through bed of solids immersed in fluids and demonstrate the knowledge of their application in filtration.	1,2	13	-
CO-4	Analyze and apply the concepts of motion of particles for the design of sedimentation system.	1,2	13	-
CO-5	Demonstrate the knowledge of agitation, mixing, storage and conveying of fluid-solid systems.	1	2	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.8	1.0	-	-	-	-	-	-	-	-	-	1.8	-	-

Course content:

Unit-I

Particle Technology: Particle shape, particle size, sphericity, mixed particles size analysis. Screens – ideal and actual screens, standard screens, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture. Industrial screening equipments- grizzly, gyratory screen, vibrating screen, trommels. Sub sieve analysis – Air permeability method, sedimentation and elutriation methods. **09Hrs.**

Unit-II

Size Reduction: Introduction, types of forces and criteria for communition, characteristics of communited products, laws of size reduction, open and closed circuit grinding. Equipments for size reduction – jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, impactors, attrition mill, ball mill, fluid energy mill, knife cutter. **10Hrs.**

Unit-III

Flow of Fluids Past Immersed Bodies: Drag, drag coefficient. Pressure drop – Ergun's, Kozeny – Carman and Burke – Plummer equations. Fluidization - conditions for fluidization, minimum fluidization velocity, types of fluidization, applications of fluidization, pneumatic conveying.

Filtration: Introduction, classification of filtration, cake filtration, batch and continuous filtration, pressure and vacuum filtration, constant pressure filtration, characteristics of filter media. Industrial filters - sand filter, filter press, leaf filter, rotary drum filter. Filter aids, application of filter aids. Principles of cake filtration, modification of Kozeny – Carman equation for filtration. **12 Hrs.**

Unit-IV

Motion of Particles Through Fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, motion of spherical particles in Stoke's region, Newton's region and intermediate region. Criterion for settling regime, centrifugal separators, cyclones and hydro cyclones.

Sedimentation: Batch settling test, application of batch settling test to design of continuous thickener. Coe and Clevenger theory, Kynch theory. Thickener design, determination of thickener area**.** **12 Hrs.**

Unit-V

Agitation and Mixing: Application of agitation, agitation equipment, types of impellers – propellers, paddles and turbines, flow patterns in agitated vessels, prevention of swirling, standard turbine design, power correlation and power calculation. Mixing of solids, types of mixers- change can mixer, Muller mixer, mixing index, ribbon blender, internal screw mixer, tumbling mixer. **Sampling, Storage and Conveying of Solids:** Sampling of solids, storage of solids, open and closed storage, bulk and bin storage. Conveyors – belt conveyor, chain conveyor, apron conveyor, bucket conveyor, bucket elevators, screw conveyor. **09Hrs.**

Reference Books:

1) McCabe, W. L., Smith, J. C. and Harriott, P., "Unit Operation of Chemical Engineering", 4/e, McGraw Hill International, Singapore, 2001.
2) Badger, W.L. and Banchero, J.T., "Introduction to Chemical Engineering", 3/e,McGraw Hill International, Singapore, 1999.
3) Coulson, J.M. and Richardson, J.F., "Chemical Engineering Vol.2", 5/e, Particle Technology and Separation Processes, 1998.
4) Foust, A.S. et.al, "Principles of Unit Operation", 3/e, John Wiley and Sons, NewYork, 1997.

18UCHC304 Chemical Engineering Drawing (2-0-2) 3

Contact Hours: 52

Course Learning Objective (CLO):

1. To increase competency in drawing through. various conventions, equipment's and sectional view in engineering drawing

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Demonstrate Symbols, proportionate equipment drawings	-	-	10
CO-2	Analyze sectional views and assembly drawing.	10	-	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	-	2.0	-	-	1.0	-	-

Course Content:

1. **Conventions:** Equipment and piping, colour codes, materials, nuts and bolts. **01L+03P Hrs.**
2. **Process Flow Diagram**: with conventions and blocks, P&ID. **01L+04P Hrs.**
3. **Proportionate Drawing of Process Equipment**: Jackets-types, Vessel Supports, Storage vessel, Reaction vessel, Heat Exchanger, Evaporator, Distillation column. **01L+03P Hrs.**
4. **Sectional Views:** Representation of the sectional planes, Sectional lines and hatching, Selection of section planes and types of sectional views. **02L+04P Hrs.**
5. **Assembly Drawings:**
   - **i.** Shaft Joints: Cotter joint with sleeve, Gib and Cotter joint, Socket and Spigot joint. **03L+05P Hrs.**
   - **ii.** Pipe joint: Flanged type, Union Joint, Expansion joint **03L+05P Hrs.**
   - **iii.** Valves: Stop valve, Lever safety valve, Rams Bottom safety valve, Non-return valve, Plug valve **04L+13P Hrs.**

Note:

- First angle projection to be followed.
- Drafter to be used for all drawings.

Reference Books:

1) Gopal Krishna, K.R., "Machine Drawing," 2/e. Subhash Publication

2) Joshi, M.V., "Process Equipment Design" 3/e, Macmillan India publication.
3) Bhat N.D., "Machine Drawing". Charotar Publishing, 50/e, 2011
4) VilbrantandDryden., "Chemical Engineering Plant Design" Publisher: New York, McGraw-Hill, 1959.

18UCHL305 Particulate Technology Laboratory (0-0-3) 1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To get hands on experience on various unit operations by conducting experiments on size separation, size reduction, filtration etc.
2. To analyze experimental data and project in the form of a report and oral presentation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the average particle diameter by sieve and sub-sieve analysis experiments.	4, 15	10	9
CO-2	Evaluate the energy consumed for the size reduction of solid samples by applying size reduction laws.	4, 15	10	9
CO-3	Calculate the medium and cake resistance in filtration equipment's.	4, 15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Performance study of size reduction using Ball mill
2. Particle Size Analysis using ICI sedimentation
3. Particle Size Analysis using Beaker decantation
4. Separation of solids using Cyclone
5. Performance study of size reduction using Drop weight crusher

6. Performance study of size reduction using Jaw crusher
7. Determination of specific cake and medium resistance using Leaf filter
8. Determination of specific cake and medium resistance using Plate and frame filter
9. Screen effectiveness studies
10. Particle Size Analysis using Sieves
11. Batch Sedimentation Test and thickener design
12. Particle Size Analysis using Air Elutriator

Note: Minimum 10 experiments to be conducted

Reference Books:

1) McCabe and Smith, "Unit Operations of Chemical Engineering" 6/e, McGraw Hill International
2) Foust A.S. et al., "Principles of Unit Operations", John Wiley and Sons

18UCHL306 Technical Analysis Laboratory (0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To get hands on experience on various analysis of materials
2. To analyze experimental data and understand the importance of Chemical analysis

Course Outcomes(COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the various properties of the solids and fluids given.	4, 15	10	9
CO-2	Estimation and characterization of the given material.	4, 15	10	9
CO-3	Analysis of various fluids with the measuring techniques used.	4, 15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Conductometric titration an Acid vs Base.
2. Standardization of potassium permanganate.
3. Determination of percentage of available chlorine present in bleaching power sample.
4. Determination of moisture content of soil and ash content of coal.
5. Determination of calorific value of solid &liquid fuels by bomb colorimeter.
6. Estimation of hardness, calcium and chlorides in water sample.
7. Determination of optimum dosage of alum of raw water.
8. Determination of bulk density, porosity and specific surface area of a sample.
9. Estimation of oil in seeds by solvent extraction method.
10. Qualitative analysis of proteins and amino acids.
11. Qualitative analysis of carbohydrates and lipids.
12. Estimation of total loss on ignition of cement sample.
13. Estimation of reducing sugar by DNS method.
14. Estimation of sulphates and nitrates in a given water sample.

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jaffery, G.H., Basset, J., et al., “Vogel’s Text book of Quantitative Inorganic Analysis” 5/e, ELBX. 1998
2) Skoog, D.A., “Principles of Instrumental Analysis” 3/e, Saunders College publishing 1985.

IV Semester

18UMAC400	Engineering Mathematics-IV	(3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLO):

1. To provide an insight into applications of conformal mapping, integration of complex functions and application of probability distributions in Engineering.

Course Outcomes (COs):

Description of the Course Outcomes: At the end of the course the student will be able to:		**Mapping to POs(1-12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Construct and use the concepts of analytic function to solve the problems arising in Engineering field.			1
CO-2	Utilize conformal transformation and complex integral to transform irregular domain onto a relatively simple domain.		1	
CO-3	Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.		1	
CO-4	Make use of the correlation and regression analysis to fit a suitable mathematical model for the statistical data.		1,2	
CO-5	Estimate the correlation, covariance using joint probability distributions. Also use student's t-distribution, Chi-square distribution as a test of goodness of it.		1,2	

Pos	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	1.8	2	-	-	-	-	-	-		-	-	-

Pre-requisites: 1.A basic course on Differentiation and integration of function.
2. A basic course on probability and statistical averages.

Contents:

Unit-I

Calculus of complex functions: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms. Construction of analytic functions: Milne-Thomson method-Problems. **07 Hrs.**

Unit-II

Conformal transformations: Introduction. Discussion of transformations $w = e^z; w = z^2, w = z + \frac{1}{z}, z \neq 0)$. Bilinear transformations- Problems.

Complex integration: Line integral of a complex function, Cauchy's theorem and Cauchy's Integral theorem. **08 Hrs.**

Unit-III

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation-problems. Regression analysis- lines of regression–problems.

Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form = $ax + b; y = ax^2 + bx + c; y = ax^b$. **08 Hrs.**

Unit-IV

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions-problems (No derivation for mean and standard deviation)-Illustrative examples. **08 Hrs.**

Unit-V

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

Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness offit. **08 Hrs.**

Reference Books:

1) B.S. Grewal "Higher Engineering Mathematics", Khanna Publishers, 44/e, 2017.
2) E. Kreyszig "Advanced Engineering Mathematics", John Wiley & Sons, 10/e (Reprint), 2016.
3) Srimanta Pal et al., "Engineering Mathematics", Oxford University Press, 3/e, 2016.

18UCHC400	Process Heat Transfer	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Solve heat transfer by conduction in solids and extended surfaces for steady state with estimation of critical insulation.	1	2	13
CO-2	Interpret and solve heat transfer by forced and natural convection	-	2	13
CO-3	Outline ofevaporators and solve heat transfer by radiation.	3	2	13
CO-4	Determine heat transfer in condensation.	13	2	3
CO-5	Analyze the performance of heat exchange equipments.	13	2	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	2.0	1.66	-	-	-	-	-	-	-	-	-	1.8	-	-

Course Content:

Unit-I

Introduction to three modes of heat transfer: Conduction convection & radiation. **Conduction:** Fourier's law, Thermal Conductivity – its variation with temperature, analogy between heat flow and electrical flow. heat transfer through composite walls, cylinders and spherical systems.Overall heat transfer coefficient. Different types of insulating materials, general properties & application of insulators,critical and optimum thickness of insulation, Extended surfaces: heat transfer from a fin, fin effectiveness and efficiency. **12 Hrs.**

Unit-II

Convection: Types of convection heat transfer**Forced Convection:**Significance of Prandtl No., Nusselt No., correlation equations for heat transfer in laminar and turbulent flows insidecircular tube and duct, Reynolds and Colburn analogy between momentum and heat transfer, **Natural Convection:** Natural convection from vertical and horizontal

surfaces, Significance of Prandtl No., Nusselt No., Grashof No Grashof and Rayleigh numbers. **10Hrs.**

Unit-III

Radiation: Radiation laws-Kirchhoff's law Stefan Boltzmann's law, Wien's law, Plank's law etc. Black body, Grey body. Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: radiation transfer between surfaces, radiation shields.

Evaporation: Types of evaporators, single effect evaporator, multiple effect evaporators: forward, mixed, parallel and backward feeds, capacity and economy of evaporators. **09 Hrs.**

Unit-IV

Condensation: drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal and vertical tube, types of condensers **09 Hrs.**

Unit-V

Heat Exchangers: Types of heat exchangers, components of a double pipe & Shell-and Tube Heat Exchangers, LMTD and correction factor,standards,fouling. Analysis of HE's-LMTD, ε-NTU method **12 Hrs.**

Reference Books:

1) J.P.Holman," Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2) Rao Y.V.C., "Heat Transfer", Editionillustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3) McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4) Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1.6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

18UCHC401	Chemical Reaction Engineering- I	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide basic understanding of kinetic models and mechanisms for homogeneous chemical reactions.
2. To understand the interpretation of reactor data and thereby exploring the rate law for chemical reactions.
3. To provide an understanding and application of rate law in design of Ideal reactors and to assess their performances based on temperature effects.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine rate, rate constant, activation energy and order of reaction.	-	1	-
CO-2	Analyze and interpret batch reactor data	4	-	1
CO-3	Design batch reactor, ideal PFR and MFR	4	2	13
CO-4	Analyze the performance of reactors with multiple reactions, recycle reactor	4	2	13
CO-5	Interpretthe effect of temperature on reactor performance.	-	2	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.5	2.0	-	3.0	-	-	-	-	-	-	-	-	1.0	-	-

Course Content:

Unit-I

Kinetics of homogeneous reactions: Scope of Chemical Reaction Engineering, classification of reactions, Rate equation and rate of reaction. Molecularity and order of reaction Factors affecting the rate of reaction. Chemical kinetics and equilibrium constant. Temperature dependency of rate constant from Arrhenius, collision, and Transition state theories. Elementary and non-elementary reactions. Kinetic models for non- elementary reactions. **08 Hrs.**

Unit-II

Interpretation of Batch Reactor Data: Constant volume batch reactor. Analysis of total pressure data, Integral anddifferential methods of analysis for constant and variable volume reactions, Half life and method of excess. Reversible first and second order reactions, series, parallel and autocatalytic reactions. **12Hrs.**

Unit-III

Ideal Reactors for Single Reaction: Ideal batch reactor, steady-state mixed and plug-flow reactors, holding, space timeand space velocity for flow reactors. **12 Hrs.**

Unit-IV

Multiple Reactions and Reactors: Design of Batch, plug and mixed flow reactors for parallel, series reactions. Recycle reactors, Yield and selectivity. **10 Hrs.**

Unit-V

Heat effects: Heat of reactions, equilibrium constant, optimum temperature progression. Conversion in reactors operated under adiabatic and nonadiabatic conditions. Reactor design by solving material and energy balance equations simultaneously. Choosing the right kind of Reactor. **10 Hrs.**

Reference Books:

1) Octave Levenspiel, "Chemical Reaction Engineering", 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2) J. M. Smith, "Chemical Engineering Kinetics", 3/e, McGraw Hill, 1981.ISBN:0-07 066574-5
3) H. Scott Fogler, "Elements of Chemical Reaction Engineering", 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

18UCHC402 Chemical Engineering Thermodynamics (3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To relate state changes in a system to the quantity of energy in the form of heat and work transferred across its boundaries.
2. Understanding of the laws of thermodynamics and their application in the analysis of chemical and engineering problems.
3. Calculating thermodynamic properties of fluids and fluid mixtures using equation of state.
4. Determining equilibrium compositions of chemical reactions and two-phase liquid/vapor mixtures.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	State thermodynamic laws, analyze and evaluate pressure, volume and temperature with equations of state for gases.	1	-	2, 13
CO-2	Evaluate the entropy changes associated with processes and	1	2, 13	3

	analyse the fundamental equations governing thermodynamics.			
CO-3	Differentiate between ideal and non- ideal solutions and calculate the partial molar properties.	1,2,3,13	-	-
CO-4	Generate VLE data for solutions using correlations and interpret their consistency.	1,2,3,13	-	-
CO-5	Determine the conversion at equilibrium and predict the effect of controllable variables on conversion.	1,2,3,13	-	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.4	2.5	-	-	-	-	-	-	-	-	-	2.4	-	-

Course content:

Unit-I

Basic Concepts and First Law of Thermodynamics: Types of properties, functions, reversible and irreversible processes, zeroth law of thermodynamics, general statement of first law of thermodynamics, first law for cyclic process and non-flow processes, heat capacity. Derivation for closed system and steady state flow process.

P-V-T Behaviour: P-V-T behaviour of pure fluids, equations of state and ideal gas law, processes involving ideal gas law, Equations of state for real gases: van der Waals equation, Redlich – Kwong equation, virial equations, principles of corresponding states. **9L+2T Hrs.**

Unit-II

Second Law of Thermodynamics: Statements, heat engines, heat pumps, concept of entropy, Carnot's principle, calculations of entropy change, Clausius Inequality, entropy and irreversibility, third law of thermodynamics.

Thermodynamic Properties of Pure Fluids: Types ofthermodynamic Properties, Work function, Gibbs free energy. Fundamental property relations: Exact differential equations, Fundamental property relations, Maxwell's equations, equations for U and H, entropy- heat capacity relations, Clapeyron equation, Gibbs-Helmholtz equation, fugacity and fugacity coefficient, determination of fugacity of pure fluids. **10L+2T Hrs.**

Unit-III

Properties of Solutions: Partial molar properties, Gibbs-Duhem equation, chemical potential, fugacity in solutions, Henry's law and dilute solutions, activity in solutions, activity coefficients, property changes of mixing, excess properties. **8L+2T Hrs.**

Unit-IV

Phase Equilibria: Criteria of phase equilibria and stability, phase equilibria in single and multicomponent systems, Duhem's theorem, vapor-Liquid equilibria, ideal and nonideal solutions, VLE at low pressures, VLE correlations, G-D equation for VLE, consistency tests, VLE at high pressures, liquid-liquid equilibrium. **8L+2T Hrs.**

Unit-V

Chemical Reaction Equilibria: Reaction stoichiometry, criteria of chemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature and pressure on equilibrium constants and other factors affecting equilibrium conversion, liquid phase reactions, heterogeneous reaction equilibria, phase rule for reacting system. **7L+2T Hrs.**

Reference Books:

1) Smith, J.M. and Vanness, H.C., "Introduction to Chemical Engineering Thermodynamics", 7/e, McGraw Hill, New York, 2005.
2) Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.
3) Rao, Y.V.C., "Chemical Engineering Thermodynamics", New Age International Publication, Nagpur, 2000.
4) Sandler and Stanley, "Chemical, Biochemical and Engineering Thermodynamics", 4/e, John Wiley, 2007. ISBN 0471661740.

18UCHC403 Pollution Control Engineering (3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To create awareness on the various environmental pollution aspects and issues and give a comprehensive insight into natural resources, ecosystem, and biodiversity.
2. To understand the different parameters, treatment methods and control techniques of various environmental pollution.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		Mapping to POs (1-12)/ PSOs(13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Outline the importance of the environment, standards and legislation of environment and interpret various waste water	-	14	3, 6, 7

	parameters.			
CO-2	Develop and design the different methods of waste water treatment techniques.	3, 6, 7	14, 15	-
CO-3	Identify the sources and effects of different types of air pollutants, their prevention and design of control techniques.	14	3, 6, 7	-
CO-4	Illustrate the different methods for handling and disposal of solid waste and control measures of noise pollution in industries	14	3, 6, 7	-
CO-5	Identify, interpret and suggest the treatment technology for different pollutants in a typical industry	14, 15	7	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	-	2.6	2.5

Course content:

Unit -I

Introduction: Importance of Environment for Mankind. Engineering, ethics and environment.Ecological systems and pollution, hydrological cycle and nutrient cycle.Damages from environmental pollution. Fundamental definition of pollution parameters- air, water and soil quality criteria, standards and legislation and acts, EIA, EIS and EMP. Air, water and soil pollution management through waste minimization. **Sources, Sampling and Analysis of Waste Water:**Water Resources. Wastewater Classification.Types of Water Pollutants. Waste Water Sampling, Methods of Analysis: DO, BOD, COD, TOC, Nitrogen, Phosphorus, Trace Elements and Alkalinity. **08 Hrs.**

Unit-II

Waste Water Treatment: Wastewater Treatment: Preliminary, Primary, Secondary and Tertiary. Advanced wastewater Treatment: Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electro dialysis cell.Design of sedimentation tanks and biological treatment processes. **09 Hrs.**

Unit-III

Air Pollution and Treatment: Definition, Sources, Classification, Properties of air pollutants, Effects of air pollution on health vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling.Analysis of air pollutants.Air pollution meteorology (generation transportation and dispersion of air pollutants). Control

methods and Equipment's for particulates and gaseous pollutants. Selection design and performance analysis of air pollution control equipment: gravity settling chambers, cyclone separator, ESPs, filters and wet scrubbers. **08 Hrs.**

Unit-IV

Solid Waste Treatment and Noise Pollution: Sources and Classification, Effect on public health, Methods of Collection, onsite handling, storage and processing techniques, Disposal Methods, Reuse, Recovery and Recycling of Solid Waste.Solids waste disposal– compositing, landfill, briquetting/gasification and incineration.Definition, Sources, Effects of Noise, and Equipment's used for Noise Measurement, Approaches for Noise Control. **07 Hrs.**

Unit-V

Case Studies: Industrial case studies – Diary, petroleum refinery, pulp and paper, fertilizer, distillery, textile processing, Cement, Thermal power plants, metallurgical industries. **07 Hrs.**

Reference Books:

1) C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2) S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill.
3) Metcalf and Eddy, "Waste Water Engineering Treatment Disposal Reuse" Tata McGraw Hill, 4/e, 2003.
4) Frank Kreith and George Tchobanoglous- "Hand book of Solid waste Management", Tata Mc-Graw Hill, 2/e.

18UCHC404	Energy Technology and Management	(3-0-0) 3

Contact Hours:39

Course Learning Objectives (CLOs):

1. Understand the utilization of conventional and non – conventional energy sources and the principle of working of related equipments.
2. Recognize the effects of current energy systems on the environment and society.
3. Study energy costs/waste minimization without affecting production and quality.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and comprehend the effects of current energy systems	2	13	1

	based on solid and gaseous fuels.			
CO-2	Analyze the principles and concepts and explain basic principles involved in solar and wind energy conversion system.	1	, 13	3, 14
CO-3	Describe the challenges and problems associated with Bio-energy and fuel cell technology, and explain its basic principles and operations.	2	1	3, 14
CO-4	Summarize the basic principle and production process of ocean and tidal energy sources with regards to future energy supply and environmental concern.	3	1,13	2,14
CO-5	Discuss the principles and need of energy audit and management programs.	14	2,13	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.8	2.25	1.66	-	-	-	-	-	-	-	-	-	2.0	1.5	-

Course Content:

Unit-I

Introduction to Energy Sources: World energy futures, Indian energy scenario, Conventional and non-conventional energy sources.**Fuels:** Classification, properties and tests and analysis of solid, liquid and gaseous fuels. **08 Hrs.**

Unit-II

Solar Energy: Solar constant, Solar radiation at earth's surface, Solar radiation geometry, Solar radiation measurement. Solar water heating, space cooling, Solar distillation, pumping and Solar cooking- Basic principles, methods, applications, advantages and limitations.**Wind Energy:** Introduction, Basic components of WECS (wind energy conversion system). Classification of WEC Systems.Types of wind energy machines- (wind energy collectors) horizontal axis, vertical axis machines. **09 Hrs.**

Unit-III

Bio-Energy: Introduction, Biomass conversion technology, Wet and Dry process,Factors affecting Bio digestion or Generation of gases, Classification of Bio gas plants, Floating Drum, Fixed Dome plants -Basic principles, Construction and Working principles, Advantages and disadvantages. **Fuel Cells**:Design and Principle

of operation, Classification, Types, Advantages and disadvantages, Conversion efficiency, Types of electrodes, Work output and EMF of Fuel Cells, Applications of Fuel Cells. **08 Hrs.**

Unit-IV

Geothermal and Ocean Energy: Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India**.Ocean Energy:** Principle of working, performance and limitations of Wave Tidal Energy. Ocean Thermal Energy-Availability, theory and working principle, performance and limitations. **07 Hrs.**

Unit-V

Energy Management: Principles and needs initiating and managing an energy management programs. **Energy Audit**: Elements and concepts, Types of Energy Audits, Energy Audit of any one chemical industries. **07 Hrs.**

Reference Books:

1) G.D. Rai, "Non-Conventional Energy Sources", 4/e Second Reprint, Khanna Publications", 1997.
2) P.C. Jain and M. Jain, "Engineering Chemistry", 10/e, 3rd Reprint, DhanpatRai and Sons, 1995.
3) S.P. Sukhatme, "Solar Energy", 2/e, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.
4) G.D. Rai, "Solar Energy Utilization", 4/e, Khanna Publications.
5) G.N.Tiwari and M.K.Ghosal, "Renewable Energy Resource: Basic Principles and Applications", Narosa Publishing House, 2004.

18UCHL405 Computational Methods and Simulation Laboratory (0-0-3) 1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the application of mathematics using computer to solve the simple Chemical Engineering problems.

Course Outcomes(COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Solve chemical engineering problems using the analytical methods and programming.	4, 5,15	10	9

CO-2	Compute the chemical engineering problems with nonlinear-algebraic equations.	4, 5,15	10	9
CO-3	Compute the chemical engineering problems with numerical integration	4, 5,15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	3.0	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – Simpson's1/3 rule.
6. Curve fitting – Least square method
7. Double pipe heat exchanger (Area, Length)
8. Bubble and dew point calculation.
9. Introduction to Unisim design Software
10. Simulation studies of flash drum
11. Simulation studies of CSTR
12. Simulation studies of Heat Exchanger.
13. Simulation studies of Mixer

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jenson, V.J. and Jeffereys, G.V., "Mathematical Methods in Chemical Engineering", Academic Press, London and New York, 1977.
2) Mickley, H.S., Thomas. K. Sherwood and Road, C.E., "Applied Mathematics in Chemical Engineering", Tata McGraw-Hill Publications, 1957.
3) S. Pushpavanam, "Mathematical Methods in Chemical Engineering", PHI
4) E. Balagurusamy, "Programming in ANSI C", 6/e, TMH 2012.

18UCHL406	Fluid Mechanics Laboratory	(0-0-3) 1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the principle, construction, working and analysis of different equipments in the fluid flow phenomena.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Calculate the discharge rate for flow measuring devices and pumps	4,15	10	9
CO-2	Distinguish the types of pipe fitting and identify their applications	4,15	10	9
CO-3	Identify the flow pattern of the fluid and evaluate the friction factor of the spiral coil	4,15	10	9
CO-4	Calculate the minimum fluidization velocity	4,15	10	9
CO-5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.2	2.2	-	-	-	-	3.0

List of Experiments:

1. Characteristics of fluidized bed.
2. Develop the characteristic curve for centrifugal pump
3. Local velocity measurement using Pitot tube.
4. Develop the characteristic curve for positive displacement pump
5. Characteristic of packed Bed
6. Significance of Reynolds number
7. Flow through spiral coil
8. Characteristics of Orifice meter and venturi meter
9. Friction in circular pipes
10. Different pipe fittings and its constant value

11. Weir characteristics

12. Pressure, velocity and elevation heads in Bernoulli's theorem

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGrawHill.
2) Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1, 5/e. Butterworth publications.
3) Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4) R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

18UCHL407 Introductory Project (0-0-2) 1

Contact Hours: 24

Course Learning Objective (CLO):

1. To identify and understand the community expectation in terms of possible engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) / PSOs(13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify the problem.	2,10	12	7, 14
CO-2	Compare the literature review and select suitable existing solutions.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Prepare work plan with economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report with proper guidelines and references.	10	8,15	9

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	3.0	3.0	3.0	3.0	-	1.0	2.0	1.0	2.25	2.5	2.0	-	1.0	2.7

Introductory project is introduced with an objective of understanding and identifying the community expectation in terms of possible Engineering solutions by applying the

fundamental knowledge of basic sciences and basic engineering courses. The project shall be engineering oriented in terms of problem definition, related literature survey and existing solutions. The team consisting of 10-12 students shall be asked to identify problems related to community and try to propose a solution. The faculty members handling the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for introductory project.

Reference Books/Material:

1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field