IV Semester:

S. No.	Course Code	Course Title	Category	Type	Credit	L	T	P
1.	22CHT251	Chemical Reaction Engineering-I	PC	Theory	4	3	1	0
2.	22CHT253	Heat Transfer Operations	PC	Theory	4	3	1	0
3.	22CHT255	Mass Transfer-I	PC	Theory	4	3	1	0
4.	22CHT254	Industrial Pollution Abatement	PC	Theory	4	3	1	0
5.	22CHT252	Chemical Technology	PC	Theory	4	3	1	0
6.	22RET291	Energy Storage*	PL/EAS	Theory	3	3	0	0
7.	22CHP256	Chemical Reaction Engineering Lab	PC	Lab	1	0	0	2
8.	22CHT257	Heat Transfer Operations Lab	PC	Lab	1	0	0	2
9.	22CHP258	Industrial Pollution Abatement Lab	PC	Lab	1	0	0	2
Total					**26**	**18**	**5**	**6**

***To be taught by Centre for Energy and Environment**

SEMESTER – IV

1. Subject Code: 22CHT251 **Course Title: Chemical Reaction Engineering-I**
2. Contact Hours: L: 3 T: 1 P: 0
3. Credits: 4 Semester: IV
4. Pre-requisite: Nil.
5. Course Objective: To understand the kinetics of single and multiple reactions and the effect of temperature on reaction systems along with the RTD and reactor model.
6. Course Outcomes: Upon completion of this course, the students will be able to:
   i. Develop rate laws for homogeneous reactions.
   ii. Analyze batch reactor data by integral and differential methods.
   iii. Design ideal reactors for homogeneous single and multiple reactions.
   iv. Understand the RTD flow behaviour model
   v. Demonstrate the temperature effect on reaction rate and design non-isothermal reactors.
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction and Kinetics of Homogeneous Reaction**: Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories.	8
2.	**Interpretation of Batch Reactor Data:** Integral and differential methods for analyzing kinetic data., constant volume reactor for zero, first, second and third order reactions, half-life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions, Variable volume batch Reactor for zero, first and second order reactions. Temperature and Reaction Rate.	8
3.	**Introduction to Reactor Design:** Ideal reactors for single reaction: Ideal batch reactor, steady state Mixed Flow Reactor, steady state PFR, Holding time and space time for flow systems. Design equation for batch, continuous stirred tank, plug flow reactors for isothermal reaction. Design for single reactions: Optimum reactor size, Size comparison, multiple reactor systems, recycle reactor, auto catalytic reactions. Design for multiple reactions: Reactions in parallel, reactions in series, series- parallel reactions.	8
4.	**Residence Time Distribution**: Residence time distribution of fluids in vessels, E, F and C curves, Dispersion model, Tank in series model. Non Isothermal PFR and CSTR, Safety issues in Non Isothermal Reactors.	8
5.	**Temperature and pressure effects on reaction:** Single reactions: Heat of reaction, equilibrium constants, graphical design procedure, optimum temperature progression, adiabatic operations. Multiple reactions: Product distribution and temperature.	6

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Levenspiel, O., "Chemical Reaction Engineering", 3rd Ed., John Wiley & Sons, Singapore.	2006
2	Fogler, H. S., "Elements of Chemical Reaction Engineering," 5th Ed., Prentice Hall of India.	2016

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Keith J. Laidler, "Chemical Kinetics" 3rd Edition, Pearson.	2003
2	Smith, J. M., "Chemical Engineering Kinetics", 3rd Ed. McGraw Hill.	1981
3	Richardson, J.F., and Peacock D.G., "Coulson and Richardson's Chemical Engineering," vol. 3, 3rd Ed., Asian Books Pvt. Ltd., New Delhi.	1998

1. Subject Code: 22CHT253 **Course Title: Heat Transfer Operations**

2. Contact Hours: L:3 T:1 P:0
3. Credits: 4 Semester: IV
4. Pre-requisite: Nil.
5. Course Objective: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries
6. Course Outcomes: Upon completion of this course the students will be able to:
   i. Understood the basic fundamentals of heat transfer and also various mode of heat transfer along with governing laws and for extended surfaces.
   ii. Understood the concept of heat transfer coefficient and its calculation for natural and forced convection using various empirical correlations.
   iii. Understood concept of boiling and condensation phenomenon and correlation for the various heat transfer coefficient.
   iv. Design heat exchanger for different applications in a chemical process plant.
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction:** Modes of heat transfer: conduction, convection, radiation. **Steady-State Conduction in One Dimension:** Fourier's Law, thermal conductivity, steady-state conduction of heat through a composite solid, cylinder and sphere. Steady-state heat conduction in bodies with heat sources: plane wall, cylinder and sphere. **Unsteady-State Heat Conduction:** Mathematical formulations and initial and boundary conditions. Analytical solution, numerical solution.	8
2.	**Heat Transfer Coefficient:** Convective heat transfer and the concept of heat transfer coefficient, overall heat transfer coefficient, heat transfer from extended surfaces, thermal contact resistance, critical insulation thickness, optimum insulation thickness. **Forced Convection:** Flow over a flat plate, thermal boundary layer, flow across a cylinder. Dimensional analysis: Buckingham Pi theorem, Dimensional groups in heat transfer. Correlations for the heat transfer coefficient: Laminar flow through a circular pipe, turbulent flow through a circular pipe, flow through a non-circular duct, flow over flat plate, flow across a cylinder, flow past a sphere, flow across a bank of tubes, heat transfer coefficient in a packed and fluidized bed. Double-pipe heat exchanger in parallel and counter-current flow.	8
3.	**Free Convection:** Introduction, heat transfer correlations for free convection: flat surface, cylinder, sphere, enclosure. Combined free and forced convection. **Boiling and Condensation:** Boiling phenomenon, nucleate boiling, Correlations for pool boiling heat transfer: Nucleate boiling, critical heat flux, stable film boiling. Forced convection boiling, condensation phenomena, film condensation on a vertical surface, turbulent film	6

	condensation, condensation outside a horizontal tube and tube bank. Condensation inside a horizontal tube, effect of non-condensable gases. Dropwise condensation.	
4.	**Radiation Heat Transfer:** Basic concepts of radiation from a surface: black body radiation, Planck's Law, Wien's Displacement Law, Stefan-Boltzmann Law, Kirchoff's Law, Gray body. Radiation intensity of a black body, spectral emissive power of a black body over a hemisphere. Radiation heat exchange between surfaces – the view factor. Radiation exchange between black bodies and between diffuse gray surfaces.	6
5.	**Evaporators:** Types of evaporators: Natural-circulation evaporators, forcedcirculation evaporators, falling film evaporators, climbing-film evaporators, agitated thin-film evaporators and plate evaporators. Principles of evaporation and evaporators; Single and multiple effect evaporators, Capacity and economy, Boiling point rise, heat transfer coefficient enthalpy of a solution. Calculations of a single effect evaporator.	6
6.	**Heat Exchangers:** Construction of a shell-and-tube heat exchanger, fouling of a heat exchanger, LMTD, temperature distribution in multi-pass heat exchangers, individual heat transfer coefficients.Types of shell-and-tube heat exchanger. Design of different type of heat exchangers.	8

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Dutta, B. K. “Heat transfer: Principles and Applications”, PHI, New Delhi	2001
2	Kern, D. Q., “Process Heat Transfer”, Tata- McGraw Hill	1950

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Holman, J. P., “Heat Transfer”, McGraw Hill, 10^{th} Ed. New York	2017
2	Chapman, A. J., “Heat Transfer”, Maxwell Macmillan	1984

1. Subject Code: 22CHT255 **Course Title: Mass Transfer I**

2. Contact Hours: L:3 T:1 P:0

3. Credits: 4 Semester: IV

4. Pre-requisite: NIL

5.Course Objective: To introduce the undergraduate students with the most important separation equipment in the process industry, and provide proper understanding of various mass transfer operations.

6. Course Outcome: Upon completion of this course, the students will be able to:

i. Solve problems related to diffusion and inter-phase mass transfer, mass transfer theories and mass transfer equipment.
ii. Perform design calculation related to absorption (plate and packed column)
iii. Solve problems related to binary and multi-component distillation

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Basics of Mass Transfer:**Physico-chemical basis of separation processes-thermodynamic considerations, Chemical Potential, stage and continuous contacting operations, concepts of equilibrium stage, operating line and tie line. Liver Rule. Introduction to Membrane Separation Processes.	4
2.	**Diffusion:** Molecular and turbulent diffusion, diffusion coefficient, Fick's Law of diffusion, dependence of diffusion coefficient on temperature, pressure and composition; measurement and estimation of diffusivity. Diffusion in multi-component gas mixtures. Diffusion in Solids: Molecular, Knudsen &surface diffusion; Inter- phase mass transfer: Mass transfer coefficients, Laminar and turbulent flow situations and Correlations, Diffusion between phases, Equilibrium solubility of gases in liquids, Various Mass transfer theories, Mass transfer in fluidized beds, Flow past solids and boundary layers, Simultaneous heat and mass transfer.	10
3.	**Absorption and Stripping:**Equipment, Gas-liquid equilibria, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, HTU, NTU & HETP concepts, Design equations for packed column, Absorption with chemical reaction and mass transfer.	8
4.	**Distillation:** Basic fundamentals of distillation, Ideal and non- ideal stages; definitions of point, stage and column efficiencies Pressure-composition, Temperature-concentration, Enthalpy-concentration diagrams for ideal and non-ideal solutions, Raoult's law and its application, Maximum and minimum boiling mixtures, concept of relative volatility, Single Stage Distillation Differential distillation, Flash vaporization, Vacuum, molecular and steam distillation. McCabe-Thiele method;Plate calculations, simple and complex fractionators. Ponchon-Savarit method, Multi-component distillation (short-cut and MESH method), Azeotropic and extractive	18

	distillation.	

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Treybal, R "Mass Transfer Operations", 3rd Ed.NewYork: McGraw-Hill.	1981
2	Sherwood T. K., Pigford R. L. and Wilke P. "Mass Transfer" McGraw-Hill.	1975
3	Geankoplis, CJ, "Transport Processes and Unit Operations", 4th Ed. Prentice Hall.	2013
4	B K Dutta, Principles of Mass Transfer and Separation Processes, PHI Learning.	2007

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Foust A.S., Wenzel, L.A., Clump, C.W., Maus,L., Anderseny, L.B., "Principles of Unit Operations" 2nd Ed., John Wiley.	2008
2	King, C. J.," Separation Processes", 2nd Ed. McGraw-Hill, NY.	2013
3	Smith, B. D., "Design of Equilibrium Stage Processes", McGraw-Hill, NY.	1963
4	McCabe, W. L., Smith, J. C. and Harriot, P., "Unit Operations of Chemical Engineering", 7th Ed., McGraw-Hill, NY.	2017
5	Coulson, J. M. and Richardson, J. F., "Chemical Engineering", Vol. I and II, 6th Ed., Elsevier.	1999

1. Subject Code: 22CHT254 **Course Title: Industrial Pollution Abatement**

2. Contact Hours: L:3 T:1 P:0
3. Credits: 4 Semester: IV
4. Pre-requisite: Nil.
5. Course Objective: To provide concepts of water and air pollution, related legislation, pollution abatement and solid waste management
6. Course Outcomes: Upon completion of this course, the students will be able to:
   i. Quantify and analyze the pollution load
   ii. Analyze/design of suitable treatment operation for wastewater
   iii. Model the atmospheric dispersion of air pollutants and design of air pollution control devices
   iv. Analyze the characteristics of solid waste, its handling &management
   v. Gained knowledge of the Environmental legislation and standards
7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Wastewater Treatment:** Characterization of Industrial wastewater, primary, secondary and tertiary treatment, segregation, screening, equalization, Disinfection, coagulation, flocculation, precipitation, flotation, sedimentation, aerobic and anaerobic treatment, Design of activated sludge system, absorption, ion exchange, membrane filtration, electrodialysis, sludge dewatering and disposal methods.	16
2.	**Air Pollution Control:** Sources and classification of air pollutants, nature and characteristics of gaseous and particulate pollutants, pollutants from automobiles. Air pollution meteorology, plume and its behavior and atmospheric dispersion, control of particulate emissions by gravity settling chamber, cyclones, wet scrubbers, bag filters and electrostatic precipitators. Control of gaseous emissions by absorption, adsorption, chemical transformation and combustion.	12
3.	**Solid Waste Management:** Hazardous and non-hazardous waste, methods of treatment and disposal, land filling, leachate treatment and incineration of solid wastes.	8
4.	Legislation, standards for water and air,Environmental regulatory legislations and standards	4

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Peavy, H. S., Rowe, D. R.,Tchobanoglous, G., "Environmental Engineering"; McGraw Hill.	1985
2	Masters, G.M., "Introduction to Environmental Engineering and Science", 3rd Ed. Prentice Hall.	1991
3	Metcalf & Eddy, Inc., "Wastewater Engineering: Treatment and Reuse", 4th Ed., Tata McGraw Hill, New Delhi.	2003

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	De Nevers, N., "Air Pollution Control Engineering", 2nd Ed., McGraw-Hill.	1999
2	Mahajan, S. P., "Pollution Control in Process Industries," Tata McGraw-Hill, New Delhi.	1985
3	Modi, P. N., "Sewage Treatment and Disposal and Waste Water Engineering," Vol. II, 17th Ed. Standard Book House, Delhi.	2020

1. Subject Code: 22CHT252 **Course Title: Chemical Technology**

2. Contact Hours: L:3 T: 1 P: 0

3. Credits: 4 Semester: IV

4. Pre-requisite: Studied unit processes and unit operations courses prescribed in Chemical Engineering syllabus

5. Course objective: To study process technologies of various organic and inorganic process industries

6. Course Outcome: Upon completion of this course, the students will be able to:

i. Understand the processes involved in manufacturing of various inorganic and organic chemicals

ii. Prepare the process flow diagrams

iii. Analyze important process parameters and engineering problems during production

7. Details of Course:

Unit No.	Contents	Contact Hours
1.	**Introduction to Chemical Engineering**: Unit operations and unit processes,functions of a Chemical Engineer, new emerging areas. Study of the following chemical industries/processes involving process details, production trends, thermodynamic considerations, material and energy balances, flow sheets, engineering problems pertaining to materials of construction, waste regeneration/recycling, and safety, environmental and energy conservation measures.	2
2.	**Industrial Gases:** Hydrogen, producer gas and water gas. **Nitrogen Industries:** Ammonia, nitric acid, nitrogenous and mixed fertilizers. **Coal Conversion technologies**	9
3.	**Chlor-Alkali Industries:** Common salt, caustic soda, chlorine, hydrochloric acid, sodaash.	7
4.	**Sulphur Industries:** Sulphuric acid, oleum. **Cement Industries:** Portland cement.	6
5.	**Agrochemicals:** Important pesticides, BHC, DDT, Malathion. **Alcohol Industries:** Industrial alcohol, Absolute alcohol.	7
6	**Oils and Fats:** Oils, Fats and Waxes, Soaps and Detergents. **Pulp and Paper Industry** **Sugar Industry**	9

8. Books:

(A) Text Books:

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Rao, M.G. and Sittig, M., Dryden's Outlines of Chemical Technology, Affiliated East West Press.	1997
2	Austin, G.T., Shreve's Chemical Process Industries, 5^{th} Ed., McGraw-Hill.	2017

(B) Reference Books:

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Faith, W.L., Keyes, D.B. and Clark, R.L., Industrial Chemicals, 4^{th}Ed., John Wiley.	1975
2	Kirk-Othmer Encyclopedia of Chemical Technology, John Wiley and Sons, Inc.	2001

1. Subject Code: 22RET291 Course Title: Energy Storage

(To be taught by Centre for Energy and Environment)

2. Contact Hours: L: 3 T: 0 P: 0

3. Credits: 3 Semester: IV

4. Pre-requisite: Nil

5. Course Objective:

CO1: To understand different aspects and parameters of energy storage.

CO2: To determine utilization, sizing, and operation of energy storage systems.

CO3: To solve energy storage system design problems.

6. Course Outcome: Upon completion of this course, the students will be able to:

i. Select and size suitable energy storage systems for any application.

ii. Compare and evaluate different energy storage systems.

7. Details of Course:

S. No.	Objectives	Contact Hours
1.	Introduction of energy storage technology, requirement for energy storage, Current status, storage services and benefits, cost performance and maturity of storage technology, methods and tools for evaluation of storage, future prospect of storage, policy and regulatory framework.	7
2.	Introduction to Electrochemical energy storage. Comparison, Ragone plot and state-of-art application, their function and deployments. Technical characteristics, introduction to battery states and their estimation methods, Performance characteristics, testing, safety, standards and system sizing, different electrochemical energy storage methods, flow battery, lead acid battery, characteristics of battery.	10
3.	Thermal energy storage (TES) methods Sensible TES, Latent TES, Thermochemical TES, Selection depending on the application. Types of storage systems Design and operation of thermal storage systems	8
4.	Hydrogen energy: hydrogen economy, Hydrogen based energy storage, hydrogen storage and transportation safety	6
5.	Mechanical energy storage systems, flywheel energy storage (FES), pumped hydropower storage (PHS), and compressed air energy storage (CAES). Comparison and application state of art including principle, function and deployments.	8

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1.	Large Energy Storage Systems Handbook Edited by Frank S. Barnes Jonah G. Levine. Publisher CRC Press Taylor & Francis Group ISBN 9781138071964	2011
2.	Energy Storage Fundamentals, Materials and Applications Edited by Robert Huggins. Publisher Springer ISBN: 978-3-319-21239-5	2016
3	Grid-Scale Energy Storage Systems and Applications Edited by Fu-Bao Wu, Ji-Lei Ye, Bo Yang ISBN:9780128152935	2019

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1.	Compressed Hydrogen in Fuel Cell Vehicles: On-board Storage and Refueling Analysis Edited by Shitanshu Sapre, Kapil Pareek, Rupesh Rohan. CRC Press Taylor & Francis Group ISBN 9781032154893	2022
2.	US DOE Energy storage handbook (https://www.sandia.gov/ess/publications/doe-oe-resources/eshb/doe-epri-nreca)	2013
3	Advances in Batteries for Medium and Large-Scale Energy Storage Edited by Maria Skyllas-Kazacos, Chris Menictas, T. M. LimISBN:9781782420224	2014

1. Subject Code: 22CHP256 Course Title: Chemical Reaction Engineering Lab
2. Contact Hours: L:0 T:0 P:2
3. Credits: 1 Semester: IV
4. Pre-requisite: CHT XXX Chemical Reaction Engineering- I
5. Course Objective: Hands on practice on the study of kinetics of homogeneous and heterogeneous reactions using different reactors and RTD studies in different reactors
6. Course outcome: Upon completion of this course, the students will be able to:

i. Run various homogeneous and heterogeneous laboratory size reactors and to determine different kinetic parameters in Batch reactor, CSTR, CSTRs in series, Spinning basket reactor, Packed bed recycle reactor etc.
ii. Development of practical skills leading to research initiatives

7. Details of Course:

Experiment No.	Objective	Contact Hours
1.	Study of a non-catalytic homogeneous reaction between sodium hydroxide and ethyl acetate in a BatchReactor and to determine: (i) Order of reaction, (ii) Rate constant k, and (iii) Effect of temperature on k and determineactivation energy E.	3
2.	Study of a non-catalytic homogeneous reaction between sodium hydroxide and ethyl acetate ina Plug Flow Reactor between and to determine: (i) Order of reaction and (ii) Rate constant k	3
3.	Study of a non-catalytic homogeneous reaction between sodium hydroxide and ethyl acetate ina series of three CSTRs and to draw the performance chart for the reactor system and evaluate the rateconstant at ambient temperature.	3
4.	Study of a non-catalytic gas solid reaction for the decomposition of $CaCO_3$ in air in a MuffleFurnace and to record the decomposition-time data for calcination of $CaCO_3$ particles and find out a suitablemodel for the reaction.	3
5.	Characterization of the given sample of Adsorbent/Catalyst and to determine its (i) Bulkdensity and (ii) Pore volume	3
6.	Study of the behaviour of a given CSTR/ Packed Bed Reactor/ CSTRs in series by using pulseinput and step input of a tracer and determine (i) Mean resistance time, (ii) Variance, (iii) Dispersion no.,and (iv) Dispersion coefficient.	3
7.	Study of the kinetics of hydrolysis of ethyl acetate in a Packed Bed Recycle Reactor filled withion exchange resin and to determine the effect of recycle ratio on the conversion.	3
8.	Study heterogeneous catalytic hydrolysis of ethyl acetate using ion exchange resin in a SpinningBasket Reactor and determine (i) Reaction rate constant (ii) Study the effect of Mass Transfer.	3

9.	Study of the kinetics of photo-catalytic oxidation of formic acid in a UV Reactor and to determine the rate constant of reaction.	3
10.	Propose an experiment based on any of the existing experimental set up ofCRE Lab. or a combination of the same. Or Propose an experimental set up (with as much details as possible) along with a suitable experiment, which is not presently existing in CRE Lab.	3

8. Books

A) Text Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Levenspiel, O., "Chemical Reaction Engineering," 3rdEd., John Wiley.	2006
2	Fogler, H. S., "Elements of Chemical Reaction Engineering," 5thEd., Prentice-Hall of India, Delhi.	2016
3	Smith, J. M., "Chemical Engineering Kinetics," 3rdEd., McGraw-Hill.	1981

(B) Reference Books

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Carberry, J. J., "Catalytic Reaction Engineering," McGraw-Hill.	1976
2	Levenspiel, O., "The Chemical Reactor Omnibook," OSU Bookstores, Corvallis, Oregon.	1996

1. Subject Code: 22CHT257 **Course Title: Heat Transfer Operations Lab**

2. Contact Hours: L:0 T:0 P:2

3. Credits: 1 Semester: IV

4. Pre-requisite: Principles of Heat Transfer

5. Course Objective: To provide hands on experience on heat transfer operations and equipment

6. Course Outcome: Upon completion of this course, the students will be able to:

   i. Understand the principles of heat transfer
   ii. Understand the operations of various heat transfer equipments
   iii. Measure physical properties and heat transfer coefficient

7. Details of Course:

Experiment No.	**Objective**	**Contact Hours**
1.	Study of Heat transfer by conduction in a metal bar	3
2.	Study of Heat transfer by conduction in a Composite metal wall	3
3.	Study of unsteady state heat transfer	3
4.	Determination of Thermal conductivity of Insulated Powder	3
5.	Study of Heat transfer by Natural convection	3
6.	Study of Heat transfer by Forced convection	3
7.	Study of Heat transfer in Agitated Vessel	3
8.	Determination of Emissivity of given material	3
9.	Study of Heat transfer in double pipe heat exchanger	3
10.	Study of Heat transfer in Shell and Tube heat exchanger	3
11.	Determination of heat transfer coefficient in boiling phenomenon	3
12.	Determination of heat transfer coefficient for Dropwise Condensation	3
13.	Determination of heat transfer coefficient for Film wise Condensation	3
14	Determination of thermal conductivity of liquids	3
15	Determination of critical heat flux from pool boiling apparatus	3

8.Books:

(A) Text **Books:**

S.No.	**Authors / Name of Book / Publisher**	**Year of Publication**
1	Dutta, B. K. “Heat transfer: Principles and Applications”, PHI, New Delhi, “Transport Phenomena”, 2^{nd} Ed., Wiley.	2001
2	Kern, D. Q., “Process Heat Transfer”, Tata- McGraw Hill,	1950

(B) Reference	**Authors / Name of Book / Publisher**	**Year of Publication**

Books**S.No.**		
1	Holman, J. P., "Heat Transfer", 10th Ed. McGraw Hill, New York.	2017
2	Chapman, A. J., "Heat Transfer", Maxwell Macmillan.	1984

1. Subject Code: 22CHP258 **Course Title: Industrial Pollution Abatement Lab**

2. Contact Hours: L:0 T:0 P:2

3. Credits: 1 Semester: IV

4. Pre-requisite: Nil.

5. Course Objective: Hands on practice to analysis the water and wastewater for some of their key parameters by standard methods and impart the practical skills leading to research initiatives.

6. Course outcome: Upon completion of this course, the students will be able to:

i. Students got hands on practice of analyzing water and wastewater for some of their key parameters by standard methods.

ii. Development of practical skills leading to research initiatives.

7. Details of Course:

Experiment No.	Objective	Contact Hours
1.	Determination of Total Solids (TS), Total Suspended Solids (TSS), and Total Dissolved Solids(TDS) of a given wastewater sample.	3
2.	Determination of Volatile Suspended Solids (VSS) and Fixed Suspended Solids (FSS) of a given water sample	3
3.	Determination of pH, Electrical Conductivity (EC), and Turbidity of a given water sample.	3
4.	Determination of Dissolved Oxygen (DO) of a given water sample byWinkler's method.	3
5.	Determination of Chemical Oxygen Demand (COD) of a given water sample.	3
6.	Determination of Oil and Grease in a given wastewater sample.	3
7.	Determination of Biological Oxygen Demand (BOD) of a given water/ wastewater sample.	3
8.	Determination of Available Chlorine in a given sample of Bleaching Powder	3
9.	Propose an experiment consistent with the theory subject of IPA and for which infrastructureis available in IPA Lab. giving complete details (as given in IPA Lab practical instructionsheet).	3
10.	Some real lifeproblem based on the course content of Industrial Pollution Abatement. Theproblem should have application of Numerical methods and/or statistics. Select a problemfrom journal research paper/ text book of the subject. The project must have somecontribution of the team commensurate with the level of the Class.	3
11.	Propose an experiment consistent with the theory subject of IPA and for which infrastructureneeds to be arranged in IPA Lab. giving complete details (as given in IPA Lab	3

	practicalinstruction sheet)	
12.	Estimation of Settling Property using Jar Test	3
13.	Estimation Water Turbidity	3

8. Books:

(A) Text Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Clesceri, L. S., Greenberg, A. E., Eaton, A. D. (Eds.),"Standard Methods forWater and Wastewater Analysis", 20thEd., American Public Health Association(APHA),Washington.	1998

(B) Reference Books

S.No.	Authors / Name of Book / Publisher	Year of Publication
1	Maiti, S. K., "Handbook of Methods in Environmental Studies", Vol. I, ABD Publishers, Jaipur.	2001
2	Mathur, R. P., "Water andWastewater Testing (Laboratory Manual)", 4thEd., Nemchand and Brothers, Roorkee.	2005