IPS Academy, Institute of Engineering & Science

(A UGC Autonomous Institute, Affiliated to RGPV, Bhopal)

Scheme & Syllabus Based on AICTE Flexible Curricula **(B. Tech)**

Chemical Engineering Department

Semester IV (II Year)

S. No.	Course Code	Course Title	Hrs./ week			Credits
			L	T	P	
1	BSC-CH401	Numerical Methods, Probability & Transform Calculus	3	1	0	4
2	PCC-CH401	Chemical Engineering Thermodynamics-II	3	1	0	4
3	PCC-CH402	Heat Transfer	3	1	2	4
4	PCC-CH403	Mass Transfer-I	3	1	2	4
5	PCC-CH404	Fuel Technology	3	1	2	4
6	PCC-CH405	Computer Applications in Chemical Engineering	0	0	2	1
7	MC-4	Constitution of India	2	0	0	0
Total			**17**	**05**	**08**	**21**
Total Academic Engagement and Credits			**30**			**21**

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BSC-CM401	**Numerical Methods, Probability and Transform Calculus**	**3L:1T:0P (04 hrs)**	**Credits:04**

Prerequisite(s): Calculus and Linear Algebra, Differential Equations and Vector Calculus

Course Objectives: The objective of this course is to serve the potential engineers with techniques of numerical mathematics, Transform calculus and their applications. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

Module-1: Numerical Methods **(09 hrs)**

Solution of algebraic and transcendental equations: Newton-Raphson method, Secant and Regula-Falsi method, Finite differences, Interpolation using Newton's forward and backward difference formulae, Newton's divided difference, Numerical differentiation, Numerical integration: Trapezoidal rule and Simpson's $1/3^{rd}$ and $3/8^{th}$ rules.

Module-2: Functions of Complex Variables **(10 hrs)**

Complex numbers, Polar form of complex numbers, Triangle inequality, Limits, Continuity and differentiability of functions of a single complex variable, Analytic functions, Cauchy-Riemann equations, Cauchy's integral theorem, Integral formula and derivatives of analytic functions, Taylor's and Laurent series, Evaluation of real integrals by Cauchy residue theorem.

Module-3: Probability and Statistics **(09 hrs)**

Mean, Median, Mode and Standard deviation, Random variables, Definition of probability and sampling, Conditional probability, Binomial, Poisson and Normal distribution, Linear regression analysis.

Module-4: Laplace Transform **(09 hrs)**

Laplace transform, Properties of Laplace transform, Laplace transform of periodic functions, Finding inverse Laplace transform by different methods, Convolution theorem, Evaluation of integrals by Laplace transforms, Solution of ODEs by Laplace transform method, Solution of simultaneous ODEs by Laplace transformation.

Module-5: Fourier Transformation **(08 hrs)**

Definition and Properties of Fourier transformation, Convolution of Fourier transformation, Fourier transformation on function spaces, Solution of ordinary and partial differential equation by Fourier transformation.

Course Outcomes:

After completion of this course, the students are able to:

1: To describe and apply Numerical methods in practical problems appearing in Chemical engineering.

2: To explain and solve mathematical problems regarding functions of complex variables.

3: To understand and use the concept of probability and statistics in engineering problems.

4: To interpret and apply the concept of Laplace transform in different problems of Chemical engineering.

5: To identify and use Fourier transform in different engineering problems.

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 10th Edition, 2018.
2. S. R. K. Iyenger, R. K. Jain, Numerical Methods, New Age International Publisher, 1st edition, 2020.
3. M. Spiegel, S. Lipschutz, J. Schiller, Complex Variables, McGraw Hill Education, 2nd Edition, 2009.
4. R. W. Hamming, Numerical Methods for Scientist and Engineers, Dover Publications,2nd edition, New York, 2016.
5. P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical Methods, S. Chand & Company, 2nd edition, 2012.
6. B. V. Ramanna, Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 2017.
7. S. Ross, A First Course in Probability, Pearson Education India, 9th Edition, 2019.
8. E. J. Watson, Laplace Transform and Applications, Publisher: Van Nostrand Reinhold, 1980.
9. P. G. Hoel, S. C. Port, C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003.
10. R. J. Beerwends, Fourier and Laplace transform, Cambridge University Press, 2003.

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PCC-CH401	**IV**	**Chemical Engineering Thermodynamics-II**	**3L:1T:0P (04 hrs)**	**Credit:04**

Prerequisite(s): Chemical Engineering Thermodynamics-I

Course objective-The objective of this course to understand the theory and applications of Solution thermodynamics, thermodynamic properties of pure fluid, and various cycles like vapor compression cycle etc.

Course content-

MODULE 1: **(10 hrs)**

Thermodynamic properties of pure fluid**,** Helmholtz free energy, Gibbs free energy Relationship among thermodynamic properties, Maxwell's relationship, Clausius equation Clausius-Clapeyron equation, Gibbs-Helmholtz equation, Joule-Thomson coefficient.

MODULE 2: **(12 hrs)**

Thermodynamic properties of homogeneous mixtures; property relationship for systems of variable compositions, partial molar properties, fugacity & fugacity-coefficient in ideal-solution, concept of fugacity departure, Activity.

MODULE 3: **(10 hrs)**

Chemical potential & its physical significance, effect of pressure & temperature on heat of reaction, concept of free energy Vant-Hoffs equation, Gibbs-Duhem relationship of free energy with equilibrium constant, chemical reaction equilibria & its applications.

MODULE 4: **(08 hrs)**

Change of mixing activity, heat effects in mixing, activity effect in gaseous mixture, Excess properties, Residual properties.

MODULE 5: **(06 hrs)**

Refrigeration, ideal reversed Carnot cycle, vapor compression refrigeration, component of vapor compression plant (compressor, condenser, expansion device, and evaporator) properties of refrigerant

Course Outcomes:

After completion of this course, the students are able to:

1: Understand thermodynamic properties of pure fluid.

2: Ability to apply the concept of partial molar properties and its importance in heterogeneous solutions.

3: Capable to apply the concept of chemical potential and its significance in equilibrium.

4: Ability to understand the concept of heat effect in mixing and activity effect.

5: Ability to understand the concept of refrigeration and its application.

Text/Reference Book-

1. K.V Narayanan (2010). A Textbook of Chemical Engineering Thermodynamics. (1st Edition). PHI learning private limited, New Delhi
2. J. M. Smith, H.C. Ness, M. Abbott (2009). Introduction to Chemical Engineering Thermodynamics. (7th Edition). McGraw Hill Education.
3. Daubert, T. E. (Thomas E.), 1937- Chemical Engineering Thermodynamics. (1st Edition McGraw-Hill) New York.
4. Stanley I. Sandler, Thermodynamics, 5th Edition, John Wiley & Sons 2017.

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PCC-CH402	**IV**	**Heat Transfer**	**3L:1T:2P (06 hrs)**	**Credits:04**

Prerequisite(s): Chemical Process Calculation

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.

Course content-

MODULE 1: **(07 hrs)**

Conduction- Modes of heat transfer one dimensional and two-dimensional, heat rate equations, Theory of insulation, critical radius calculations, types of insulation material, conduction through slab, cylinder and sphere.

MODULE 2: **(08 hrs)**

Convective heat transfer- Heat transfer in boundary layer and in films, natural and forced convection, co/counter/cross current contacting for heat transfer, individual and overall heat transfer coefficient, fouling factor.

MODULE 3: **(06 hrs)**

Radioactive heat transfer- Black body radiation, concept of shape factor, methods of determination of shape factor, radiation exchange in enclosure with black surfaces.

MODULE 4: **(10 hrs)**

Heat transfer under phase change conditions-boiling and condensation of pure components, heat flux temperature diagram for boiling and condensation under vertical and horizontal surfaces, nucleate & pool boiling, effect of surface condition on condensation, correlation for heat transfer under condensation. Evaporation- Type of evaporators and their applications single and multiple effect evaporators, design and operation of forward– backward and mixed feed operations, effect of boiling point elevation and hydrostatic head,vapor recompression.

MODULE 5: **(09 hrs)**

Heat Exchange equipment- Introduction to general design of double pipe,shell and tube heat exchangers, condensers, extended surface equipment's. Heat exchanger equation– coil to fluid, jacket to fluid.

Course Outcomes:

After completion of this course, the students are able to:

1: Understand modes of heat transfer, heat rate equation, theory of insulation.

2: Solve convective heat transfer problems, individual and overall heat transfer coefficient, fouling factor.

3: Solve radiative heat transfer problems.

4: Understand heat transfer under phase change conditions, boiling & condensation and to design forward and backward evaporators.

5:Design of double pipe shell and tube exchanger, condensers, extended surface equipment

Text/Reference Book-

1. McCabe W.L., Smith J.C. and Harriott P. (2017) Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.
2. Holman J.P.9th Ed, 2001, Heat Transfer, New York, McGraw Hill.
3. Incropera F.P. and Dewitt D.P. Fundamentals of Heat and Mass Transfer. Wiley; 5th Edition John Wiley. 2001

List of experiments-To ascertain the…

1. Thermal conductivity of metal rod.
2. Equivalent thermal conductivity of composite wall.
3. Heat transfer coefficient in force convection.
4. Heat transfer coefficient in Natural convection.
5. Heat transfer coefficient with the help of Stefan Boltzmann Apparatus.
6. Emissivity of the test plate by emissivity measurement apparatus.
7. Heat transfer coefficient in double pipe heat exchanger.
8. Heat transfer characteristics of a shell and tube heat exchanger (heating/cooling) of water.
9. Heat transfer coefficient in parallel and counter flow heat exchanger.
10. Rate of evaporation using an open pan evaporator.
11. Rate of condensation of pure water vapor and to determine the heat transfer coefficient.
12. Demonstrate the film-wise drop-wise condensation and determination of the heat transfer coefficient.
13. Study the single effect evaporator and find out the heat transfer coefficient.

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Chemical Engineering Department

PCC-CH403	**IV**	**Mass Transfer-I**	**3L:1T:2P (06 hrs)**	**Credits:04**

Prerequisite(s): Chemical Process Calculation

Course Objective: The Objective of these subject diffusion phenomena, fundamentals of mass transfer and techniques involved in mass transfer operations of distillation and absorption.

Course content-

Module 1: **(09 hrs)**

Introduction: Mass transfer operation, Classification of mass transfer operations, choice of separation methods.Molecular diffusion: Fick's law of diffusion, steady state diffusion, multicomponent diffusion, measurement and prediction of diffusion coefficients, molecular diffusion in gases, liquid and solids, Knudsen diffusion, surface diffusion, eddy diffusion. Local and overall mass transfer coefficients.

Module 2: **(09 hrs)**

Fundamentals of Mass Transfer: Interphase mass transfer, two phase flow, local overall mass transfer coefficients and their inter relationships, analogies in mass, heat and momentum transfer. Mass transfer theories: film theory, penetration theory and surface renewal, material balance for co current and counter current processes, column internals: types of trays/ plates and packing, concept of ideal stage and stage efficient.

Module 3: **(08 hrs)**

Vapor liquid equilibrium, boiling point diagram, relative volatility, flash and differential distillation for two component mixture, steam distillation, azeotropic distillation, extractive distillation

Module 4 **(10 hrs)**

Continuous and Differential contact Distillation: Rectification, reflux ratio, calculation, optimum reflux ratio, open steam, partial condenser, multiple feed and multiple product calculations, enthalpy concentration diagram, Panchon-Savarit method for calculation of number of theoretical plates, Fensky and Underwood equation for minimum numbers of plate calculation, batch distillation.

Module 5: **(09 hrs)**

Absorption: Absorption and stripping of dilute mixtures: Fundamentals of absorption, equilibrium curves, choice of solvent, co-current and counter current contacting fluids, Minimum solvent flow rate, estimation of number of ideal stages – graphical and analytical methods, significance of absorption factor, design of packed column, calculation of NTU and HTU, Concept of HETP.

Course Outcomes:

After completion of this course, the students are able to:

1: Understand the knowledge of mass transfer by applying principles of diffusion, mass transfer coefficients
2: Estimate the mass transfer coefficients and their inter relationship. Understanding different theories of mass transfer analogies and inter-phase mass transfer.
3: Understand the vapor liquid equilibrium and different type of distillation.
4: Evaluate the number of theoretical stages by different methods.
5: To determine NTU, HTU, HETP and height of packed bed used for absorption.

Text/Reference Book-

1. McCabe W.L., Smith J.C. and Harriott P. (2017) Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.
2. Coulson J. Richardson M., (2013) Chemical Engineering (5^{th} Edition) Vol 2; Oxford:Butterworth Heinmann.
3. Treybal R.E., (1981) Mass Transfer Operation (3^{rd} Edition), New York: Mc. Graw Hill
4. Sherwood, T.K., Pigford R.L. and Wilke, C.R.,(1975) Mass Transfer;New York: Mc. Graw Hill.
5. Dutta. B.K., (2007) Principles of Mass Transfer and Separation Processes (1^{st} Edition), Delhi:PHI Learning.

List of Experiment-Determination of….

1. Diffusion coefficient, or diffusivity, of given liquid in air.
2. Mass transfer coefficient in gas liquid system by evaporation.
3. Study the rates and phenomena of diffusion into gases flowing through the pipe.
4. Study different types of plates and packing.
5. Study the rates and phenomena of diffusion into gases flowing through the pipe and also to verify the Sherwood & Gilliland correlations.
6. Vapor-liquid equilibrium and boiling point diagram for a binary liquid mixture.
7. Validate Rayleigh equation for differential distillation of binary system.
8. Rate of distillation by steam distillation.
9. Studies on packed tower distillation unit.
10. Studies on the sieve plate distillation unit.
11. Studies on bubble cap distillation column.
12. Mass transfer coefficient for absorption of CO_2 in NaOH solution in packed column.packed column.

PCC-CH404	**IV**	**Fuel Technology**	**3L:1T:2P (06 hrs)**	**Credits:04**

Prerequisite(s): Applied Chemistry

Course objective-The objective of this course to understand processing and limitations of fossil fuels (coal, petroleum and natural gas) and necessity of harnessing alternate energy resources such as solar, wind, nuclear, geothermal tidal and biomass. Also understand and practice various characterization techniques for fuels.

Course content-

MODULE 1: (08 hrs)

Solid Fuels & Coal Carbonization:Coal & lignite reserves in India, classifications of coal, washing of coal, analysis of coal, proximate and ultimate analysis. Mechanism of low temperature carbonization and high temperature carbonization, byproduct recovery from coke oven, properties of coke coal, grinding, pulverization, briquetting of solid fuels.

MODULE 2: (08 hrs)

Liquid Fuels:Origin of petroleum production, distillation, thermal & catalytic cracking, coking, reforming, isomerizations, crude oil classification, reserves of hydrocarbon in India, introduction to petroleum refining and processing.

MODULE 3: (08 hrs)

Petroleum Products Properties and Its Utilization:Petroleum product and their utilization, diesel, petrol, blending of petrol for octane number boosting, AVL (aviation liquid fuel), kerosene, fuel & furnace oil, testing of petroleum product: flash point, pore point, fire point, octane number, cetane number, viscosity and viscosity index, API.

MODULE 4: (08 hrs)

Gaseous fuels:Natural gas, synthesis gas, producer gas, water gas, coal gas, LPG, CNG and hydrogen as a fuel, composition properties and uses.

MODULE 5: (08 hrs)

Renewable Energy Sources and Fuel cell:Types of solar cell and fabrication, wind energy, principles of tidal energy. Principle and working of fuel cell, various types, construction and its application

Course Outcomes:

After completion of this course, the students are able to:
1: Recall coal reserves in India & explain washing of coal & Discuss coal classification
2: Interpret mechanism of low and high temp carbonization

3: Illustrate the knowledge of petroleum processing like cracking, reforming, distillation and isomerization
4: Estimate properties of petroleum product and understand composition and properties of gaseous fuel
5: Discuss principle, working & construction of fuel cell and support renewable energy sources

Text/Reference Book-

1. Sarkar S; Fuel and Combustion; Orient Long men Ltd.
2. Gupta OP; Fuel and Combustion; Khanna Publication.
3. Gary; Refining of Petroleum Technology.
4. D.P. Kothari, K. C. Signal, R. Rajan, Renewable Energy Sources and Emerging technology, PHI Learning pvt. Ltd.
5. G.D. Roy, Non-Conventional Energy Source, Khanna Publisher.
6. J. Twidel, T Weir, Renewable Energy Sources, Taylor and Francis.

List of experiments-

1. Proximate analysis of the given coal sample.
2. Determine the viscosity of the given oil sample by Redwood Viscometer. No. 1 and No. 2
3. Calculate the viscosity of a given oil sample by Saybolt viscometer.
4. Estimate the viscosity of a given coal tar with the help of tar viscometer.
5. Evaluate the flash and fire points of the given oil sample by Penskey Martin'sapparatus.
6. Find the flash and fire points of the given oil sample by Abel's apparatus.
7. Determine the flash and fire points of the given oil sample by Cleveland apparatus.
8. Investigate the carbon residue of the given oil by Conradson method.
9. Calculatethe cloud and pour point of given oil sample by cloud and pour point apparatus.
10. Find the composition of given gas by Orsat apparatus.
11. Study the method of determination of calorific value by Bomb-Calorimeter.

PCC-CH405	**IV**	**Computer Application in Chemical Engineering**	**0L:0T:2P (02 hrs)**	**Credits:01**

Course objective: The objective of the course to understand the application Microsoft (MS) excel to solve chemical engineering numerical

List of experiments-

1. Introduction to MS excel and discuss basic operations
2. Explain the diverse function in MS excel
3. Unit conversions of chemical process.
4. Ability to solve material balance solution using MS excel
5. Discuss energy balance solution using MS excel.

MC-4	**IV**	**Constitution of India**	**2L:0T:0P (02 hrs)**	**Credits:00**

Course Objective: The objective of this course is to familiarize the students with the feature of the Indian constitution, laws, democracy etc.

Course content-

MODULE 1: **(08 hrs)**

Historical background: Formation and working of constituent assembly, formation and working of drafting committee, commencement of Indian constitution, Dr. Ambedkar's ideas of reservation in constitution.

MODULE 2: **(08 hrs)**

Important feature of the constitution: Preamble, fundamental rights, directive principles of state policy, fundamental duties, centerstate relation.

MODULE 3: **(08 hrs)**

Parliamentary democracy: Loksabha, Rajyasabha, central exclusive president, prime minister, and central ministry, Vidhansabha, Vidhanparishad and state executive (Governor, Chief minister, Minister of state).

MODULE 4: **(08 hrs)**

Special provisions in Indian constitution: finance commission contingency fund, consolidated fund, public service commissions, election commission, safeguards for SC, ST and backward classes, provisions for emergency and constitutional amendments, Indian judiciary supreme court and high court.

Course Outcomes:

After completion of this course, the students are able to:

1: Commencement of Indian Constitution

2: Features of Indian constitution

3: Working and functions of Parliamentary house

4: Provisions in Indian Constitution

Text/Reference Book-

1. Austin, G. (1999), The Indian Constitution, Oxford, Oxford University Press
2. Pylee, M. V. (2016), India's Constitution (16 Edition), New, Delhi, S. Chand Publication
3. Kumar, R. (2011), Ambedkar and Constitution (1st Edition), New Delhi, Commonwealth Publication Pvt. Ltd.

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