DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY LUCKNOW

Evaluation Scheme & Syllabus

For

B.Tech. 2nd Year

(Chemical Engineering)

On

AICTE MODEL CURRICULUM

(Effective from the Session: 2019-20)

DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY LUCKNOW

B.TECH (CHEMICAL ENGINEERING)

SEMESTER- III

Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KOE031-38/ KAS302	Engineering Science Course/Maths IV	3	1	0	30	20	50		100		150	4
2	KAS301/ KVE 301	Technical Communication/Universal Human values	2 3	1 0	0 0	30	20	50		100		150	3
3	KCH301	Material and Energy Balance	3	1	0	30	20	50		100		150	4
4	KCH302	Chemical Engineering Fluid Mechanics	3	1	0	30	20	50		100		150	4
5	KCH303	Heat Transfer Operations	3	0	0	30	20	50		100		150	3
6	KCH351	Chemical Engineering Fluid Mechanics Lab	0	0	2				25		25	50	1
7	KCH352	Heat Transfer Operations Lab	0	0	2				25		25	50	1
8	KCH353	Soft Computing Lab	0	0	2				25		25	50	1
9	KCS354	Mini Project or Internship Assessment*	0	0	2			50				50	1
10	KNC301/ KNC302	Computer System Security/Python Programming	2	0	0	15	10	25		50			0
11		MOOCs (Essential for Hons. Degree)											
		Total										**950**	**22**

*The Mini Project or internship (3-4 weeks) conducted during summer break after II semester and will be assessed during III semester.

SEMESTER- IV														
Sl. No.	**Subject Codes**	**Subject**	**Periods**			**Evaluation Scheme**				**End Semester**		**Total**	**Credit**
			L	**T**	**P**	**CT**	**TA**	**Total**	**PS**	**TE**	**PE**		
1	KAS402/ KOE041-48	Maths IV/Engineering Science Course	3	1	0	30	20	50		100		150	4
2	KVE401/ KAS401	Universal Human Values/ Technical Communication	3 / 2	0 / 1	0 / 0	30	20	50		100		150	3
3	KCH401	Mechanical Operations	3	0	0	30	20	50		100		150	3
4	KCH402	Chemical Reaction Engineering-I	3	1	0	30	20	50		100		150	4
5	KCH403	Chemical Engineering Thermodynamics	3	1	0	30	20	50		100		150	4
6	KCH451	Mechanical Operations Lab	0	0	2				25		25	50	1
7	KCH452	Chemical Reaction Engineering Lab	0	0	2				25		25	50	1
8	KCH453	Numerical Methods of Analysis Lab	0	0	2				25		25	50	1
9	KNC402/ KNC401	Python Programming/Computer System Security	2	0	0	15	10	25		50			0
10		MOOCs (Essential for Hons. Degree)											
		Total										**900**	**21**

SEMESTER-III

SUBJECT CODE:**KCH 301** COURSE TITLE: **Material And Energy Balance**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **III (ODD)**

L:3 T:1 P:0 C:4 **PRE-REQUISITE:** NIL

OBJECTIVE: To provide basic knowledge of principles of material and energy balances applied to chemical engineering systems.

COURSE OUTCOME:

After successful completion of the course the students will be able to:

1. Apply steady-state and unsteady state material and energy balance on a system.
2. Analyze all the stiochiometric and balances being applied on a system undergoing chemical process.
3. Design equipment with inlet and outlet; including recycle- bypass streams for a chemical process.

REFERENCE BOOKS:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Himmelblau D.M. and Riggs J. B.,“ Principles and Calculations in Chemical Engineering”, 8th Ed., Prentice Hall of India.	2012
2.	Felder R.M. and Rousseau R.W., “Elementary Principles of Chemical Processes”, 3rd Ed.., John Wiley.	2005
3.	Bhatt B.I. and Vora S.M., “Stoichiometry”, 5th Ed., Tata McGraw-Hill	2010
4.	Narayanan K.V. and Lakshmikutty B., “Stoichiometry and Process Calculations”, Prentice Hall of India.	2006
5.	Hougen D.A., Watson K.M. and Ragatz R.A., “Chemical Process Principles”, Part-I, 2nd Ed., CBS Publishers.	1995

COURSE DETAILS:

Units	S. No.	Contents	Lecture Hours
I	**1.**	**Introduction:** Units and dimension in chemical engineering**,** units conversion of dimensional equations, stoichiometric and composition relations, concept of degrees of freedom and linear independence of a set of equations.	**5**
	2.	**Material Balance:** Concept of material balance, open and closed systems, steady state and unsteady state, multiple component system, selection of a basis, problem solving strategy.	**4**
II	**3.**	**Material Balance without Chemical Reaction for Single and Multiple Units:** Conservation of mass/atom, material balance for Systems without chemical reactions involving single unit and multiple units.	**5**
	4.	**Material Balance with Chemical Reaction for Single and Multiple Units:** Concept of excess reactant, extent of reaction, Material balance for systems with chemical reactions involving single unit and multiple units.	**6**
III	**5.**	**Recycle, Bypass, Purge and Industrial Applications:** Calculations for a cyclic processes involving recycle/ purge/ bypass, material balances involving gases, vapors, liquids and solids and use of real gas relationships, material balance involving gases, vapors, liquids & solids and uses of real gas relationships, vapor-liquid equilibrium and concepts of humidity & saturation, analysis of systems with bypass, recycle and purge, analysis of processes involving condensation, crystallization and vaporization.	**7**
IV	**6.**	**Energy Balance:** Conservation of energy with reference to general energy balance with and without chemical reactions, chemical engineering problems involving reversible processes and mechanical energy balance.	**4**
	7.	**Applications of Energy Balance:** Calculations of heat of change of phase (solid – liquid & liqid – vapor), heat of reaction, heat of combustion, heat of solutions and mixing, determination of temperatures for adiabatic and non-adiabatic reactions, use of psychometric and enthalpy-concentration diagrams.	**6**
V	**8.**	**Simultaneous Material and Energy Balances:** Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems.	**3**

	9.	**Unsteady State Material and Energy Balances:** Transient materials and energy balances involving with and without chemical reactions.	2
		TOTAL	**42**

SUBJECT CODE:**KCH 302** COURSE TITLE:**Chemical Engg. Fluid Mechanics**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **III (ODD)**

L:3 T:1 P:0 C:4 **PRE-REQUISITE:** NIL

OBJECTIVE: To present the fundamental insights of fluids and their static and dynamic behaviors and fluid machineries, etc.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Understand the properties and flow of fluid.
2. Analyse the model and prototype.
3. Explain the factors influencing velocity profiles for laminar and turbulent flow.
4. Design the pumps and compressors for optimum operation.

REFERENCE BOOKS:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Nevers N.D., "Fluid Mechanics For Chemical Engineers", 3rd Ed., McGraw Hill Higher Education.	2005
2.	Cengel Y.A. and Cimbala J.M. "Fluid Mechanics: Fundamentals and Applications", 2nd Ed. McGraw-Hill	2010
3.	Balachandran P. "Engineering Fluid Mechanics", PHI Learning Pvt Ltd., New Delhi	2012
4.	Munson B.R., Young D.F., Okiishi T.H. and Huebsch W.W., "Fundamentals of Fluid Mechanics", 6th Ed., Willey	2010
5.	White F.M. "Fluid Mechanics", 7th Ed. Tata McGraw-Hill	2010
6.	Rajput, R. K., "Textbook of Fluid Mechanics", S. Chand and Co., New Delhi.	1998

COURSE DETAILS:

Units	S. No.	Contents	Lecture Hours
I	1.	**Introduction:** Fundamental concepts of fluids; Fluid statics, kinematics and dynamics; Properties of fluids.	3
	2.	**Fluid Statics:** The basic equation of fluid statics; Pressure – depth relationship; Pressure forces on plane and curved surfaces; Buoyancy and stability; Forces on immersed and submerged bodies; Pressure measurements; Pressure in accelerated rigid body motions.	6
II	3.	**Elementary Fluid Kinematics:** Lagrangian and Eulerian descriptions; Flow visualization – streamline, pathline, streakline and timeline, profile plots; Description and classification of fluid motions; Rotational, irrotational, inviscid and potential flows; Deformation of fluids; System and control volume representation; Reynolds transport theorem.	6
III	4.	**Dynamic Analysis of Flow:** Conservation of mass, linear and angular momentum, and energy; Eulers equation of motion, Bernoulli theorem; Navier-Stokes equations.	6
	5.	**Dimensional Analysis, Similitude and Modeling:** Dimensional homogeneity and analysis; Methods of finding dimensionless numbers; Selection of variables, Rayleigh and Buckingham's π method; Common dimensionless numbers and their physical significance; Model and Prototypes; Complete and incomplete similarity.	3
IV	6.	**Internal Incompressible Viscous Flow:** General characteristics of pipe flow – laminar, turbulent, entrance region, fully developed; Fully developed laminar/turbulent flow in pipe – shear stress distribution and velocity profiles; Energy correction factors; Energy and hydraulic grade lines; Major and minor losses in pipes, fittings, pipe network; Friction factor.	7
	7.	**Flow Measurements:** Flow rate and velocity measurements – Pitot tube, orifice meter, venturimeter, rotameter, notches and weirs.	2
V	8.	**Fluid Handling Machinery:** Classification; Positive-displacement pumps and compressors, centrifugal pumps and compressors, Axial flow pumps and compressors, compressor efficiency. Characteristics of centrifugal pumps; NPSH; Selection of pumps.	6
	9.	**Agitation and Mixing:** Agitated vessels; Blending and mixing; Suspension of solid particles; Dispersion operations; Agitator selection and scale up.	3
		TOTAL	**42**

SUBJECT CODE:**KCH 303**

COURSE TITLE:**Heat Transfer Operations**

EXAMINATION DURATION: **3 Hrs.**

SEMESTER: **III (ODD)**

L:3 T:0 P:0 C:3

PRE-REQUISITE: NIL

OBJECTIVE: To provide basic knowledge about heat transfer and its processes used in Chemical Process Industries.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. apply basic principles of heat transfer for designing heat transfer systems.
2. model heat transport systems and develop predictive correlation.
3. assess and evaluate various designs for heat transfers and optimize the solution

REFERENCE BOOKS:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Holman, J. P., Heat Transfer, 10th Edition., Tata McGraw-Hill Education Private ltd.	**2011**
2.	Kern, D.Q., Process Heat Transfer, 1st Edition, Tata McGraw-Hill Education Private ltd.	**2001**
3.	Cengel Y.A. and Ghajar A.J., "Heat and Mass Transfer: Fundamentals and Applications", 4th Ed., McGraw Hill	**2010**
4.	McCabe, W.L, Smith J.C, and Harriot, P, Unit Operations in Chemical Engineering, 7th Edition, McGraw-Hill, Inc.	**2004**
5.	Coulson, J.M. and Richardson, J.F, Chemical Engineering, Vol. I, 6th Edition, Elsevier India.	**1999**

COURSE DETAILS:

Units	S. No.	Contents	Lecture Hours
I	**1.**	**Introduction**: Importance of heat transfer in Chemical Engineering operations - Modes of heat transfer.	**2**

	2.	**Conduction**: Fourier's law of heat conduction; One dimensional steady state heat conduction equation for flat plate; Hollow cylinder - Heat conduction through a series of resistances; Thermal conductivity measurement; Effect of temperature on thermal conductivity; Heat transfer in extended surfaces; Numerical Methods for solving conduction heat transfer problem (Explicit and Implicit methods); Stability criteria.	**6**
II	**3.**	**Convection** Concepts of heat transfer by convection; Natural and forced convection; Analogies between transfer of momentum and heat; Reynold's analogy; Prandtl and Coulburn analogy. Dimensional analysis; Correlations for the calculation of heat transfer coefficients; Heat transfer coefficient for flow through a pipe; Flow through non circular conduit; Flow past flat plate; Extended surface. Lumped system analysis; Heat transfer augmentations.	**6**
III	**4.**	**Radiation**: Heat transfer by radiation; Emissive power; Black body radiation; Emissivity, Kirchoff's law; Stefan - Boltzman law; Plank's law; Radiation between surfaces.	**7**
	5.	**Evaporator**: Classification and use of evaporators in process industries, effect of boiling point rise on evaporator performance, Single effect and multiple effect evaporation - Design calculation for single and multiple effect evaporation.	**4**
IV	**6.**	**Boiling**: Characteristics, nucleate pool- and forced convection- boiling, boiling mechanism and curve, heat transfer correlations, heat pipes.	**4**
	7.	**Condensation**: Mechanism and types of condensation of vapor; Drop wise and film wise condensation; Nusselt equation for vertical and horizontal tubes; Condensation of superheated vapours; Effect of non-condensable gasses on rate of condensation.	**5**
	8.	**Heat Exchangers**: Parallel and counter flow heat exchangers; Log mean temperature difference; Single passand multi pass heat exchangers; Double pipe; Shell and tube; Plate and frame heat exchangers; use of correction factor charts; Heatexchangers effectiveness; Number of transfer unit; Chart for different configurations;Fouling factors; Design of heat exchangers; Selection criteria and application of Heat exchanger; Introduction to TEMA type heat transfer and applications	**8**

			TOTAL	**42**

SUBJECT CODE:**KCH 351** COURSE TITLE:**Chemical Engg. Fluid Mechanics Lab**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **III (ODD)**

L:0 T:0 P:2 C:1

OBJECTIVE: To determine the various parameters related to fluid flow in pipes and in open channels.

LAB OUTCOME:

On completion of the experiments, the students will be able to

1. Calculate coefficient of discharge through v-notch, venturimeter, and orificemeter..
2. Determine friction losses through different pipes and fittings.
3. Calculate the efficiency of centrifugal pump.
4. Study different types of flow and analyse Bernoulli's law.

LIST OF EXPERIMENTS:

1. To find the flow rate using a V notch
2. To find the friction losses in a Straight pipe and in a Bend pipe.
3. Study of Pipe fittings and Valves
4. To study the working principle of a centrifugal pump and determine its efficiency experimentally.
5. Determination of coefficient of velocity, coefficient of resistance, coefficient ofcontraction.
6. To determine the pressure drop in a packed bed.
7. Determination of discharge coefficient with Reynolds Number in case of an orifice meter and a venturi meter.
8. Study and verification of the flow pattern in a Bernoulli's apparatus
9. To determine the minimum fluidization velocity in a fluidized bed.
10. Determination of the fluidization index, segregation index in a fluidized bed
11. Determine the Reynolds number and study different types of flow.

SUBJECT CODE:**KCH 352**

COURSE TITLE:**Heat Transfer Operations Lab**

EXAMINATION DURATION: **3 Hrs.**

SEMESTER: **III (ODD)**

L:0 T:0 P:2 C:1

PRE-REQUISITE: NIL

OBJECTIVE: To determinethe amount of heat exchange in various modes of heat transfer includingcondensation & boiling for several geometries.

LAB OUTCOME:

On completion of this course, the students will be able to

1. Determine the thermal conductivity of different materials.
2. Calculate the rate of heat transfer through different types of heat ex-changers in different flow patterns.
3. Study the natural convection phenomena and temperature distribution in various setups(like composite wall, lagged pipe etc.).

LIST OF EXPERIMENTS:

1. To find out the thermal conductivity of liquids.
2. To find out the thermal conductivity of a metal rod.
3. Find out the Heat Transfer Coefficient during drop wise and film wise condensation.
4. Find out the Heat Transfer Coefficient in a vertical and a horizontal condenser.
5. To find out the emissivity of a surface.
6. To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall.
7. To find out the average heat transfer co-efficient of vertical cylinder in natural convection.
8. To find out the Stefan Boltzman's constant and compare with the theoretical value.
9. To find out the relation between insulation thickness and heat loss.
10. To find out the overall heat transfer co-efficient of a double pipe heat exchanger.
11. To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger.
12. Study and operation of a long tube evaporator.

SUBJECT CODE:**KCH 353** COURSE TITLE:**Soft Computing Lab**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **III (ODD)**

L:0 T:0 P:2 C:1 **PRE-REQUISITE:** NIL

OBJECTIVE: To use different softwares for solving basic problems of engineering.

LAB OUTCOME:

On completion of this course, the students will be able to

1. Understand the importance of software.
2. Solve basic chemical engineering problems using MS-EXCEL and MATLAB.

LIST OF EXPERIMENTS:

Experiment using MS-EXCEL and MATLAB.

1. To apply material balance on any chemical engineering unit operation.
2. To apply energy balance on any chemical engineering unit operation.
3. To work on heat transfer problems.
4. To work on a exchanger or evaporator designing using kern's method.
5. To find out effect on conversion and time of operation in a batch reactor.
6. To design a distillation column, feed height and number of trays in a column using Mccabe thiele method.

SUBJECT CODE:**KCH 354** COURSE TITLE:**Mini Project/ Seminar**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **III (ODD)**

L:0 T:0 P:2 C:1 **PRE-REQUISITE:** NIL

OBJECTIVE: To develop presentation skills and enhance knowledge on various fields in chemical engineering through technical seminars.

COURSE DETAILS:

Students will undergo a mini project in departmental laboratories under the guidance of a teacher and present the same at the end of semester OR They will study some technical topic and present the same.

SEMESTER-IV

SUBJECT CODE:**KCH 401** COURSE TITLE: **Mechanical Operations**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **IV (EVEN)**

L:3 T:0 P:0 C:3 **PRE-REQUISITE:** NIL

OBJECTIVE: To impart Knowledge on particle size analysis, size reduction, separation of solid particles from fluids and flow through porous media.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Measure the particle size,
2. Estimate the crushing efficiency of different type's crushers.
3. Explain the particle sedimentation.
4. Design the storage area for the different types of solids.

REFERENCE BOOKS:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Backhurst, J. R. and Harker J. H.,"Coulson and Richardson Chemical Engineering", Vol. II",5th Ed., Butterworth-Heinemann.	2004
2.	McCabe W.L., Smith J.C and Harriott P., "Unit Operations of Chemical Engineering", 7th Ed. , McGraw Hill.	2005
3.	Foust, A. S., Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., *Principles of Unit Operations*, 2nd Edition., John Wiley & Sons	1980
4.	Brown G.G., *Unit Operations*, CBS Publishers & Distributors	2005
5.	Hiramath R.S., Kulkarni A.P., *Unit Operations of Chemical Engineering*, 9th Edition, Everest Publications	2004
6.	Narayanan C.M. & Bhattacharya B.C., "Mechanical Operation for Chemical Engineers –Incorporating Computer Aided Analysis", Khanna Publishers.	1992

COURSE DETAILS:

Units	S. No.	Contents	Lecture Hours
I	**1.**	**Particles Size Analysis:** General characteristics of solids; Different techniques of size analysis; Shape factor; Surface area determination; Estimation of particle size; Screening methods and equipment; Screen efficiency; Ideal and actual screens.	**6**
II	**2.**	**Size Reduction:** Methods of size reduction; Classification of equipments; Crushers; Grinders; Disintegrators for coarse, Intermediate and fine grinding; Laws of size reduction; Energy relationships in size reduction; power requirement; Work index	**6**
	3.	**Size Enlargement:** Principle of granulation; Briquetting; Pelletisation; Flocculation.	**3**
III	**4.**	**Particle Separation:** Gravity settling; Sedimentation; Thickening; Elutriation; Double cone classifier; Rake classifier; Bowl classifier; Centrifugal separation; Continuous centrifuges; Design of basket centrifuges; Industrial dust removing equipment; Cyclones; Hydro cyclones; Electrostatic - Magnetic separators; Heavy media separations; Floatation; Jigging	**7**
IV	**5.**	**Flow through Porous media (Filtration):** Theory of filtration,Batch and continuous filters, Filtration equipments; Rotary drum filter; Plate and frame filter; Leaf filter; Notch filter; Sand filter; Bag filter; Selection; Operation; Filter aids. Flow through filter cake and Filter media; Compressible and incompressible filter cakes; Design of filters and optimum cycle of operation.	**7**
	6.	**Fluidization:** Fluidization characteristics, aggregative and particulate fluidization, voidage and minimum fluidization velocity,terminal velocity of particles; entrainment; pressure drop in fluidization.	**4**
V	**7.**	**Mixing and agitation:** Mixing of liquids (with or without solids); Mixing of powders; Ribbon blender; Screw blender; Double cone blender; High viscous mixer; Banbury mixer; Selection of suitable mixers; Power requirement for mixing	**5**
	8.	**Storage and conveying of solids:** Bunkers; Silos; Bins; Hoppers; Transportation of solids in bulk; Conveyer selection; Types of conveyers; Belt Conveyor; Bucket conveyor; Screw conveyor; Pneumatic conveyor; Their performance and characteristics.	**4**
		TOTAL	**42**

SUBJECT CODE:**KCH 402**

COURSE TITLE**: Chemical Reaction Engineering-I**

EXAMINATION DURATION: **3 Hrs.**

SEMESTER: **IV (EVEN)**

L:3 T:1 P:0 C:4

PRE-REQUISITE: NIL

OBJECTIVE: To provide the comprehensive knowledge of reaction engineering and chemical reactors.

COURSE OUTCOME:

On completion of this course, the students will be able to

1. Identify the reaction type and their kinetics.
2. Design the reactor for the batch and continuous chemical process.
3. Understand the Ideal and Non – Ideal Reactors.

REFERENCE BOOKS:

S. No.	**Name of Authors / Books / Publishers**	**Year of Publication/ Reprint**
1.	Levenspiel O, Chemical Reaction Engineering, 3rd Edition, Wiley India Pvt Ltd.	2010
2.	Smith, J.M, Chemical Engineering Kinetics, 3rd Edition McGraw.	2014
3.	Fogler.H.S., Elements of Chemical Reaction Engineering, 4th Edition, Phi Learning Pvt Ltd (RS).	2009
4.	Froment. G.F. & K.B.Bischoff,Chemical Reactor Analysis and Design, 3rd Edition, Wiley.	2010
5.	Butt, J.B., “ Reaction Kinetics and Reactor Design” 2nd Ed., CRC Press	2000

COURSE DETAILS:

Units	S. No.	Contents	Lecture Hours
I	**1.**	**Rate Equations:** Rate equation – elementary - non-elementary reactions - theories of reaction rate and temperature dependency - Design equation for constant and variable volume batch reactors - analysis of experimental kinetics data - integral and differential analysis.	**8**
II	**2.**	**Design of Reactors:** Design of continuous reactors - stirred tank and tubular flow reactor, recycle reactors - combination of reactors - size comparison of reactors.	**9**
III	**3.**	**Design of Multiple Reactors:** Design of reactors for multiple reactions – consecutive - parallel and mixed reactions – factors affecting choice - optimum yield and conversion - selectivity, reactivity and yield.	**9**
IV	**4.**	**Non – isothermal Reactors:** Non-isothermal homogeneous reactor systems - adiabatic reactors - rates of heat exchanges for different reactors - design for constant rate input and constant heat transfer coefficient - operation of batch and continuous reactors - optimum temperature progression.	**8**
V	**5.**	**Non Ideal Reactors:** The residence time distribution as a factor of performance; residence time functions and relationship between them in reactor; basic models for non-ideal flow; conversion in non ideal reactors.	**8**
		TOTAL	**42**

SUBJECT CODE:**KCH 403** COURSE TITLE:**Chemical Engg. Thermodynamics**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **IV (EVEN)**

L:3 T:1 P:0 C:4 **PRE-REQUISITE:** NIL

OBJECTIVE: To apply the laws of thermodynamics in solving problems related to flow processes and phase equilibrium of heterogeneous and reacting systems

COURSE OUTCOME:
On completion of this course, the students will be able to
1. Identify the thermodynamic property of the pure substance and mixture.
2. Know the basic principles of refrigeration and liquefaction process.
3. Understand the relation between thermodynamic and chemical reactions

REFERENCE BOOKS:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Smith, J.M., VanNess, H.C., & Abbot M.C, Introduction to Chemical Engineering Thermodynamics, 7th Edition, Tata Mcgraw Hill Education Private Limited.	2009
2.	Narayanan K.V, Text Book of Chemical Engineering Thermodynamics, Phi Learning Pvt. Ltd-New Delhi.	2013
3.	Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles Part II", Thermodynamics, John Wiley.	1970
4.	Dodge, B.F., Chemical Engineering Thermodynamics,1st Edition, 6th im edition McGraw-Hill,.	1944
5.	Sandler, S.I., Chemical,Biochemical and Engineering Thermodynamics, 4th Edition, Wiley.	2006

COURSE DETAILS:

Units	S. No.	Contents	Lecture Hours
I	**1.**	**Thermodynamic Laws and Property Relations:** Laws of thermodynamics and their applications; PVT behaviour of pure substances; PVT behaviour of mixtures; Generalized equations of state;Joule's experiment; Carnot cycle and Carnot theorems; Thermodynamic property relations; Maxwell relations; Partial derivatives and Jacobian method; Residual properties; Partial molar properties; Excess properties of mixtures; Thermodynamic property tables and diagrams,	**10**
II	**2.**	**Properties of Solutions and Phase Equilibria:** Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity; Application of phase rule; Vapour-liquid equilibrium; Phase diagrams for homogeneous systems and for systems with a miscibility gap; Effect of temperature and pressure on azeotrope composition; Liquid-liquid equilibrium; Ternary liquid liquid equilibrium.	**8**
III	**3.**	**Correlation and Prediction of Phase Equilibria:** Activity coefficient; Composition models; thermodynamic consistency of phase equilibria; Application of the correlation and prediction of phase equilibria in systems of engineering interest particularly to distillation and liquid extraction processes.	**8**
IV	**4.**	**Chemical Reaction Equilibria:** Definition of standard state; standard free energy change and reaction equilibrium constant; evaluation of reaction equilibrium constant; prediction of free energy data; equilibria in chemical reactors, calculation of equilibrium compositions for homogeneous chemical reactors; thermodynamic analysis of simultaneous reactions.	**8**
V	**5.**	**Refrigeration:**Principles of refrigeration; methods of producing refrigeration; liquefaction process; coefficient of performance; evaluation of the performance of vapour compression and gas refrigeration cycles.	**8**
		TOTAL	**42**

SUBJECT CODE:**KCH 451**

COURSE TITLE:**Mechanical Operations Lab**

EXAMINATION DURATION: **3 Hrs.**

SEMESTER: **IV (EVEN)**

L:0 T:0 P:2 C:1

PRE-REQUISITE: NIL

OBJECTIVE: Generate familiarity with process equipment and develop engineeringjudgment.

LAB OUTCOME:

On completion of this course, the students will be able to

1. Measure the particle size.
2. Estimate the crushing efficiency of different type's crushers.
3. Calculate medium and filter resistance of filters.
4. Estimate the pressure drop in packed and fluidized bed

LIST OF EXPERIMENTS:

1. Determination of average particle size of a mixture of particles by sieve analysis.
2. Study and operation of Jaw crusher and thereby verification of Ritinger's constant.
3. Determination of reduction ratio, maximum feed size and theoretical capacity of crushing rolls.
4. Study of Ball mill and comparison of its critical speed with the operating speed.
5. Study and operation of a Hammer mill thereby finding its reduction ratio.
6. Study and operation of a cyclone separator and thereby finding its efficiency of separation.
7. Study and operation of a Magnetic separator and thereby finding its efficiency of separation.
8. Study and operation of a Gyratory Crusher and thereby finding its reduction ratio
9. To find the cake and filter medium resistance of Plate and Frame Filter press.
10. To find the filter medium resistance of a Vacuum Leaf Filter.

SUBJECT CODE:**KCH 452**

COURSE TITLE:**Chemical Reaction Engg. Lab**

EXAMINATION DURATION: **3 Hrs.**

SEMESTER: **IV (EVEN)**

L:0 T:0 P:2 C:1

PRE-REQUISITE: NIL

OBJECTIVE: To provide the comprehensive knowledge of reaction engineering and chemical reactors.

LAB OUTCOME:

On completion of this course, the students will be able to

1. Analyse the reaction type and their kinetics.
2. Design the reactor for the batch and continuous chemical process.

LIST OF EXPERIMENTS:

1. Find out kinetic constant and study conversion of a given reaction in a batch reactor
2. Find out kinetic constant and study conversion of a given reaction in a plug flowreactor
3. Find out kinetic constant and study conversion of a given reaction in a CSTR
4. Study and operation of an adiabatic batch reactor
5. Study of a reversible reaction in a batch reactor
6. To determine energy of activation of reaction of ethyl acetate with sodium hydroxide
7. Find out specific rate contant and activation energy of a reaction in a plug flow reactor
8. To determine reaction equilibrium constant of reaction of acetic acid with ethanol.
9. To determine changes in free energy, enthalpy and entropy for the reaction of potassium iodide with iodine.
10. Study and operation of a cascade CSTR

The reaction of disappearance of phenolphthalein in NaOH solutions may be used for experiments 1 and 2.

SUBJECT CODE:**KCH 453**

COURSE TITLE:**Numerical Methods Of Analysis Lab**

EXAMINATION DURATION: **3 Hrs.** SEMESTER: **IV (EVEN)**

L:0 T:0 P:2 C:1 **PRE-REQUISITE:** NIL

OBJECTIVE: To teach the student various numerical methods toanalysis the problems of linear, nonlinear and ODE equations, interpolation and approximation, numerical differentiation and integration etc.

LAB OUTCOME:

On completion of this lab, the students will be able to

1. Compare thecomputational methods for advantages and drawback,
2. Implement the computational methods using any ofexisting programming languages, test such methods and compare between them,
3. Identify thesuitable computational technique for a specific type of problems and develop thecomputational method that is suitable for the underlying problem.

LIST OF EXPERIMENTS:

Use of following Techniques in C/C++ Language or Matlab software

1. Solution of single non-linear algebraic equations by Newton Raphson method.
2. Solution of single non-linear equations by Regulafalsi method.
3. Solution of system of linear simultaneous by Gauss Elimination method.
4. Solution of system of linear simultaneous equation by gauss seidel method and successive over relaxation method.
5. Solution of single first order ordinary differential equations by fourth order Runge-Kutta method.
6. Solution of Heat equations (Parabolic equations) by finite difference method.
7. Solution of Laplace equations (elliptic equation) by finite difference method.
8. Solution of wave equations (Hyperbolic equation) by finite difference method.
9. Finding Newton’s interpolatory polynomial for n points.
10. Finding Newton’s interpolatory polynomial based on finite difference table for n points.
11. Simpson’s 3/8-rule.9.