

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

**LUCKNOW**



**Study & Evaluation Scheme with Syllabus**

**for**

**B.Tech. Second Year**

**Chemical Engineering**

**On**

**Choice Based Credit System**

**(Effective from the Session: 2017-18)**

**2<sup>nd</sup> Year III-SEMESTER**

S. No.	Subject Code	Subject Name	L-T-P	ESE Marks	Sessional		Total	Credit
					CT	TA		
1.	ROE030 to 039/ RAS301	Science Based Open Elective/ Mathematics-III	3-1-0	70	20	10	100	4
2.	RVE301/ RAS302	Universal Human Values & Professional Ethics/ Environment & Ecology	3-0-0	70	20	10	100	3
3.	RCH301	Environmental Pollution Monitoring & Control	3-0-0	70	20	10	100	3
4.	RCH302	Mechanical Operation	3-0-0	70	20	10	100	3
5.	RCH303	Material & Energy Balance	3-1-0	70	20	10	100	4
6.	RCH304	Chemical Engg. Fluid Mechanics	3-0-0	70	20	10	100	3
7.	RCH351	Environmental Pollution Monitoring & Control Lab	0-0-2	50	30	20	100	1
8.	RCH352	Mechanical Operation Lab	0-0-2	50	30	20	100	1
9.	RCH353	Computer Application Lab	0-0-2	50	30	20	100	1
10.	RCH354	Chemical Engg. Fluid Mechanics Lab	0-0-2	50	30	20	100	1
11.	RME101*	Elements of Mechanical Engineering*	3-1-0	70	20	10	100*	--
12.	RCE151*	Computer Aided Engineering Graphics*	0-0-3	50	30	20	100*	--
Total							1000	24

CT: Class Test

TA: Teacher Assessment

L/T/P: Lecture/ Tutorial/ Practical

**\*B.Tech. II<sup>nd</sup> year lateral entry students belonging to B.Sc. Stream, shall clear the subjects RCE151/RCE251 and RME101/201 of the first year Engineering Programme along with the second year subjects.**

**Science Based Open Electives:**

- a. ROE030/ROE040 Manufacturing Process
- b. ROE031/ROE041 Introduction to soft computing
- c. ROE032/ROE042 Nano Science
- d. ROE033/ROE043 Laser System and Application
- e. ROE034/ROE044 Space Science
- f. ROE035/ROE045 Polymer Science & Technology
- g. ROE036/ROE046 Nuclear Science
- h. ROE037/ROE047 Material Science
- i. ROE038/ROE048 Discrete Mathematics
- j. ROE039/ROE049 Applied Linear Algebra

**2<sup>nd</sup> Year IV-SEMESTER**

S. No.	Subject Code	Subject Name	L-T-P	ESE Marks	Sessional		Total	Credit
					CT	TA		
1.	RAS401/ ROE040 to 049	Mathematics-III/ Science Based Open Elective	3-1-0	70	20	10	100	4
2.	RAS402/ RVE401	Environment & Ecology/ Universal Human Values & Professional Ethics	3-0-0	70	20	10	100	3
3.	REC408	Process Instrumentation	3-0-0	70	20	10	100	3
4.	RCH401	Mass Transfer-I	3-0-0	70	20	10	100	3
5.	RCH402	Chemical Engineering Thermodynamics	3-1-0	70	20	10	100	4
6.	RCH405	Heat Transfer	3-0-0	70	20	10	100	3
7.	RCH451	Mass Transfer-I Lab	0-0-2	50	30	20	100	1
8.	RCH452	Chemical Process Instrumentation Lab	0-0-2	50	30	20	100	1
9.	RCH453	Seminar	0-0-2			100	100	1
10.	RCH455	Heat Transfer Lab	0-0-2	50	30	20	100	1
11.	RME201*	Elements of Mechanical Engineering*	3-1-0	70	20	10	100*	--
12.	RCE251*	Computer Aided Engineering Graphics*	0-0-3	50	30	20	100*	--
Total							1000	24

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**Science Based Open Electives:**

- a. ROE030/ROE040 Manufacturing Process
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- e. ROE034/ROE044 Space Science
- f. ROE035/ROE045 Polymer Science & Technology
- g. ROE036/ROE046 Nuclear Science
- h. ROE037/ROE047 Material Science
- i. ROE038/ROE048 Discrete Mathematics
- j. ROE039/ROE049 Applied Linear Algebra

# **RCH301: ENVIRONMENTAL POLLUTION MONITORING & CONTROL**

## **UNIT I**

**Introduction:** Ecology & Environment, Biodiversity, Interaction of man and environment, Overall picture of Environmental pollution, Ambient air and water quality criteria, Standards and Acts-Indian, EPA& EURO, Effects and control of noise, thermal and radioactive pollution.

## **UNIT II**

**Air Pollution:** Types of pollutants, Dispersion of pollutant in the atmosphere, Gaussian dispersion model, Meteorological factors, Stability and inversion of atmosphere, Plume Behaviour, Control of air pollution from stationary and mobile sources, Methods of measuring and sampling of gaseous and particulate pollutants in ambient air and industrial waste gases, measurement of smoke density and visibility .Control of gaseous pollutants-SO<sub>x</sub>, NO<sub>x</sub>, H<sub>2</sub>S, VOCS, Auto exhaust. Stack design, Classification, selection and design of equipment's like cyclones, electrostatic precipitators, bag filters, wet scrubbers, settling chambers.

## **UNIT III**

**Water Pollution:** Waste water characteristics – Physical and chemical composition, Biochemical oxygen demand (BOD), Pathogenic bacteria and chemical toxicity. Types of pollutants in waste water of chemical industries, Methods of sampling, preservation of samples and analysis. Methods for the treatment of liquid wastes to control pollution, Classification viz. physical, chemical and biological methods, Selection and design of equipment like hydrocyclone, settling tanks, filters, ion- exchange.

## **UNIT IV**

**Solid Wastes Management:** Characterization of solid wastes, Problems of collection and handling, Various processing techniques used in solid waste management such as compaction, incineration, Composting, landfills and biological Processing, Solid waste as resource material.

## **UNIT V**

Pollution abatement in important chemical industries like fertiliser, petroleum refineries and petrochemicals, Pulp and Paper, Pharmaceuticals, Tannery, Sugar, Distillery, food processing , cement and electroplating.

### **Text Books**

1. Howard S. Peavy, DR Rowe & C. Tchobonoglous “Environmental Engineering”, McGraw Hill (1984).
2. Metcalf & Eddy, “Waste Water Engineering Treatment, Disposal & Reuse”, Tata McGraw Hill (2003).

### **Reference Books**

1. Werner Strauss, ‘Air Pollution Control: Measuring and monitoring air pollutant’, Wiley (1978).
2. Werner Strauss, ‘Air Pollution Control part -II, Wiley (1978).
3. Pandey, GN and Carney, GC, "Environmental Engineering", Tata McGraw Hill (1991).

## **RCH302: MECHANICAL OPERATIONS**

### **UNIT I**

Types of Mechanical Operations, screen analysis, particle size distribution, particle size measurement, Surface area measurements, statistical mean diameters, relevant equations and problems.

### **UNIT II**

Laws of crushing and grinding. Classification of crushing and grinding equipment. Construction and working principle of crushers and grinders.

### **UNIT III**

Classification of conveyors, Storage of solids in bulk protected and unprotected piles, bins, silos, hoppers, mass flow and funnel flow Bins, Flow assisting devices, feeders. Mixing of solids, blending, kneading. Weighing of bulk solids, batch and continuous weighing techniques.

### **UNIT IV**

Rare and dense medium separation, classifiers, magnetic separation, electrostatic separator, floatation and elutriation, continuous thickeners, decantation, centrifugal separation, Gravity settling, cyclone separators, bag filters, scrubbers.

### **UNIT V**

Classification of filters, theory of filtration, cake resistance. Fluidization with and without carryover of particles, minimum fluidization, terminal velocity of particles, entrainment, pressure drop in fluidization.

### **BOOKS:**

1. Momentum transfer operation: S.K. Gupta, TMC, 1979.
2. Unit Operations of Chemical Engineering: McCabe and Smith, TMC
3. Chemical Engineering Vol. I: Coulson & Richardson, Pergamon, 1979

## **RCH303: MATERIAL & ENERGY BALANCE**

### **UNIT I**

Basic and derived units, use of model units in calculations, Methods of expression, compositions of mixture and solutions, Ideal and real gas laws - Gas constant - calculations of pressure, volume and temperature using ideal gas law, Use of partial pressure and pure component volume in gas calculations, applications of real gas relationship in gas calculation.

### **UNIT II**

Stoichiometric principles, application of material balance to unit operations like distillation, evaporation, crystallization, drying etc., Material balance with chemical reaction, Limiting and excess reactants, recycle, bypass and purging

### **UNIT III**

Unsteady state material balances, calculation of absolute humidity, molal humidity, relative humidity and percentage humidity, use of humidity in condensation and drying, Humidity chart, dew point.

### **UNIT IV**

Determination of Composition by Orsat analysis of products of combustion of solid, liquid and gas fuels, calculation of excess air from orsat technique and problems, heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible heat and latent heats, evaluation of enthalpy.

### **UNIT V**

Standard heat of reaction, heats of formation, combustion, solution, mixing etc., calculation of standard heat of reaction, effect of pressure and temperature on heat of reaction, Energy balance for systems with and without chemical reaction, unsteady state energy balances. Introduction to Computer aided calculations-steady state material and energy balances.

### **BOOKS:**

1. Bhatt, BL, VORA, S.M., "Stoichiometry", Tata McGraw-Hill, 1976.
2. Hougen, OA, Watson, K.M and Ragatz, RA, "Chemical Process Principles Part-I", John Wiley and Asia Publishing, 1970.
3. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering ", Fourth Edition, Prentice Hall Inc., 1982.
4. Whitwell, JC, Tone, RK, "Conservation of Mass and Energy", McGraw-Hill, 1973.
5. Process Calculation for Chemical Engineering, Second Revised Edition, Chemical Engineering Education Development Centre, IIT Madras, 1981.

## **RCH304: CHEMICAL ENGG. FLUID MECHANICS**

### **UNIT I**

Properties of fluids, fluid statics, Forces on fluids, pressure depth relationship for compressible and incompressible fluids, Forces on submerged bodies, Rigid body motion, pressure measurements, Euler's equation, Bernoulli's theorem.

### **UNIT II**

Kinematics of flow, Description of velocity field, Stream functions, Angular velocity, Fluids in circulation, Irrotational flow, Dimensional analysis, Buckingham Pi Theorem, Dimensionless numbers and their physical significance, Similitude Criteria.

### **UNIT III**

Fluid flow: Laminar and turbulent flows, Pressure drop in pipes, pipe fittings and pipe network, friction factor, Conservation of mass, momentum and energy, Mechanical engineering Bernoulli's equation .

### **UNIT IV**

Flow measuring devices for chemical plants, venturimeter, orifice meter, nozzle, Rotameter, pitot tube and v-notch.

### **UNIT V**

Pumping and compressing of chemicals and gases, reciprocating pumps, rotary pumps, centrifugal pumps and blowers, NPSH and calibrations, mixing and agitation, types of mixers and their selection, power requirement, compressible fluid flow, introductory concepts of two-phase flow.

### **BOOKS:**

1. Gupta, Vijay and SK Gupta, "Fluid Mechanics and its Applications", Wiley Eastern, New Delhi (1984).
2. Rajput, RK, "Text Book of Fluid Mechanics", S. Chand and Co., New Delhi (1998).
3. Jain, AK, "Fluid Mechanics including Hydraulic Machines", Khanna Publishers, Delhi (2007).
4. Bansal, RK, "Fluid Mechanics and Hydraulic Machines", Laxmi Publications (P) Ltd., New Delhi (2005).
5. Gupta, SK, "Momentum Transfer Operations", Tata McGraw Hill, New Delhi (1982).

### **RCH351: ENVIRONMENTAL POLLUTION MONITORING & CONTROL LAB**

1. To determine the Biochemical Oxygen Demand of a Given Sample of Wastewater
2. To determine Dissolved Oxygen in a Given Sample by Azide Modification Method
3. To find Alkalinity of Water Sample by Indicator Method
4. To determine Suspended Solids of Given Water Sample
5. To determine the Total Hardness of Water using EDTA Method
6. To determine the Turbidity of Water Sample using Nephelometric Method
7. To determine pH Value of a Given Water Sample
8. To determine the COD of Waste Water Sample by using Close Reflux Method.
9. To determine the COD of Waste Water Sample by using Open Reflux Method

### **RCH352: MECHANICAL OPERATION LAB**

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 Rittinger'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.

### **RCH353: COMPUTER APPLICATION LAB**

Solution of some selected chemical engineering problems to develop skill for computer applications, programme writing and numerical analysis. Use of commercial software packages such as MATHCAD, MATLAB, Aspen Plus, Design II etc.

### **RCH354: CHEMICAL ENGG. FLUID MECHANICS LAB**

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 of contraction.
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.



# **REC408: PROCESS INSTRUMENTATION**

## **UNIT I**

Importance of measuring of Instruments in Process Control, Classification of Instruments, Elements of an Instruments, Static & Dynamic Characterization of Instruments, Errors in measurements & Error Analysis, Selection of instrument for a particular Measurement, transducers.

## **UNIT II**

Measurement of Temperature: Thermocouples, Resistance Thermometer, Expansion Thermometers, Pyrometers.

## **UNIT III**

Measurement of Pressure & Vacuum, Hydrostatic type , Elastic Element type, Electrical Type and other type of instruments like McLeod Gauge, Thermocouple gauge, Knudson Gauge, Ionization Gauge.

## **UNIT IV**

Instruments for Measurement of Flow rate & level: Variable Area & variable head flow meters, Volumetric and Mass flow rate meters, Linear velocity measurement systems, Anemometers, Pressure type, Resistance & Capacitance type, Sonic & Ultrasonic, Thermal type Level meters.

## **UNIT V**

Instruments for Measurement of Viscosity: Redwood, Saybolt, Engler, Cup & Cone type, Rheo & other types of viscometers.

### **Books:**

1. Eckman, D.P., Industrial Instrumentation, Wiley Eastern Ltd., New York 1990.
2. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers.

# RCH401: MASS TRANSFER-I

## UNIT I

**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, Diffusion between phases, Equilibrium solubility of gases in liquids, Mass transfer theories, Mass transfer in fluidized beds, Flow past solids and boundary layers, Simultaneous heat and mass transfer.

## UNIT II

**Absorption and Stripping:** Equipments, 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.

## UNIT III

**Humidification and Dehumidification:** Vapour liquid equilibrium and enthalpy for a pure substance, vapour pressure temperature curve, Vapour gas mixtures, Definition and derivations of relationships related with humidity Fundamental concept of humidification, Dehumidification and water cooling, Wet bulb temperature, Adiabatic and non-adiabatic operations, Evaporative cooling, Classification and design of cooling towers.

## UNIT IV

**Drying:** Solid-gas equilibria, Different modes of drying operations, Definitions of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, Continuous drying, Design of continuous dryers.

## UNIT V

**Crystallisation:** Equilibrium yield of crystallization, Heat and mass transfer rates in crystallization, Theories of crystallization, Factors governing nucleation and crystal growth rates, Controlled growth of crystal., Classification and design of crystallizers.

### Text Books

1. Treybal, R "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, (1980).
2. Sherwood T. K., Pigford R. L. and \_ilkeP. "Mass Transfer" McGrawHill (1975).

### Reference Books

1. Foust, AS et.al., "Principles of Unit Operations" John Wiley (1980).
2. Geankoplis, CJ, "Transport Processes and Unit Operations", 3rd ed. Prentice Hall.(1993)

# **RCH402: CHEMICAL ENGINEERING THERMODYNAMICS**

## **UNIT I**

Basic concept and definitions in thermodynamics, first, second and third laws of thermodynamics and its application in engineering problems, energy balance for open and closed systems. Entropy and entropy balance for open systems.

## **UNIT II**

An Introduction to Vapour-Liquid Equilibria, qualitative behaviour of the vapour-liquid equilibria (VLE), Simple models for vapour liquid equilibria: Raoult's and Henry's laws, dew point and bubble point calculations, VLE by modified Raoult's law and K-value correlations.

## **UNIT III**

**Solution Thermodynamics:** Theory and Applications, fundamental property relation. The chemical potential and phase equilibria. Partial properties, equations relating molar and partial molar properties, partial properties in binary solutions, relations among partial properties, ideal gas mixtures, fugacity and fugacity coefficient for pure species, VLE for pure species, fugacity of a pure liquid, fugacity and fugacity coefficient for species in solution, the fundamental residual property relation, fugacity coefficients from the virial equation of state and generalized correlations, the ideal solution, the Lewis/Randall rule, excess properties. The excess Gibbs energy and the activity coefficient, nature of excess properties.

## **UNIT IV**

**Chemical Reaction Equilibria:** The reaction coordinate. Multireaction stoichiometry. Application of equilibrium criteria to chemical reactions. The standard Gibbs energy change and equilibrium constant. Effect of temperature on the equilibrium constant. Evaluation of equilibrium constants. Relation of equilibrium constants to composition. Gas-phase and liquid-phase reactions. Equilibrium conversions for single reactions. Single phase reactions.

## **UNIT V**

Topics in Phase Equilibria The gamma/phi formulation of VLE. VLE from cubic equations of state. Equilibrium and stability. Liquid-liquid equilibrium. Vapour-liquid-liquid equilibrium. Solid-liquid equilibrium. Osmotic equilibrium and osmotic pressure.

## **BOOKS**

1. Cengel Y.A. and Boles M.A.; Thermodynamics: An Engineering Approach
2. Smith, J. M.; Introduction to chemical engineering thermodynamics.

# **RCH405: HEAT TRANSFER**

## **UNIT I**

Introduction to heat transfer and general concepts of heat transfer by conduction, convection and radiation, Conduction: Basic concepts of conduction in solids, liquids, gases, steady state temperature fields and one dimensional conduction without heat generation e.g. through plain walls, cylindrical and spherical surfaces, composite layers, etc. Insulation materials, critical and optimum insulation thickness. Extended surfaces, fins and their applications. Introduction to unsteady state heat transfer.

## **UNIT II**

Convection: Fundamentals of convection, Basic concepts and definitions, natural and forced convection, hydrodynamic and thermal boundary layers, laminar and turbulent heat transfer inside and outside tubes. Determination of individual and overall heat transfer coefficients, heat transfer in molten metals.

## **UNIT III**

Radiation: Basic laws of heat transfer by radiation, black body and gray body concepts, view factors, Kirchhoff's law, solar radiations, combined heat transfer coefficients by convection and radiation.

## **UNIT IV**

Heat transfer with phase change: Condensation of pure vapors, film wise and drop wise condensation, loading in condensers and basic calculation on condensers. Heat transfer in boiling liquids, boiling heat transfer coefficients. Evaporation: Elementary principles, types of evaporators, Single and multiple effect evaporators and their calculations.

## **UNIT V**

Heat transfer equipment: Classification, principles and design criteria, types of exchangers, viz. double pipe, shell and tube, extended surface. Furnaces and their classification and application.

## **BOOKS :**

1. Holman, JP, "Heat Transfer", 9th ed. McGraw Hill (1989).
2. Coulson, JM & Richardson, JF, "Chemical Engineering: Vol-1", 6th ed. Butterworth-Heinemann
3. McAdams, W. H., "Heat Transmission", 3rd ed., McGraw-Hill (1954).
4. Kern, DQ, "Process Heat Transfer", McGraw Hill Book (1950).
5. Badger, WL & Bancharo, JT, "Introduction to Chemical Engineering", Tata McGraw Hill.

### **RCH451: MASS TRANSFER-I LAB**

1. Study the performance and determination of Equilibrium relationships
2. Mass transfer coefficients
3. Diffusion coefficients
4. Separation factors of the experiments with differential distillation
5. Flash vaporization, vapor liquid equilibrium
6. Liquid-liquid extraction
7. Solid-liquid extraction
8. Ion exchange and membrane separation.

### **RCH452: CHEMICAL PROCESS INSTRUMENTATION LAB**

1. Calibration of thermocouple/Bimetallic thermocouple/Resistance thermocouple.
2. Calibration of Pressure gauge/ Pneumatic pressure recorder/ Differential pressure recorder.
3. Calibration of Orificemeter/ Venturimeter / Rotameter/ Gas flow meter.
4. Estimation of viscosity by Redwood/ Saybolt/ Ostwald viscometer.
5. Calibration of pH meter.
6. Calibration of Conductivity meter.

### **RCH453: SEMINAR**

The purpose of this course is to prepare our students for better communication skill and discussions.

### **RCH355/ RCH455: HEAT TRANSFER LAB**

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.