

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	Mass Transfer Operations-II	Subject Code	CL20611CL
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

### Unit – I

Molecular and eddy diffusion in fluids, Two film theory, Measurement and calculation of diffusivities, mass transfer coefficient and their correlation, analogies in transfer process, mass transfer in packed and fluidized beds.

### Unit – II

**Distillation:** Vapor – liquid equilibrium, boiling point diagram partial vaporization and condensation and relative volatility, flash distillation and differential distillation, steam distillation, azeotropic distillation and extractive distillation, multicomponent distillation

### Unit – III

Continuous distillation with rectification, calculation of number of plates – Lewis soresl Method, McCabe Thiele Method. Reflux ratio, economic reflux ratio, multiple feeds and side streams.

### Unit – IV

Minimum reflux Ratio, Fenske Underwood Equation. Plate efficiency, use of enthalpy concentration method. Packed Column, height equivalent to theoretical plate. Transfer Units and batch distillation.

### Unit – V

Design of packed tower, principles of absorption and rate of absorption. Overall coefficient, H.T.U. method, and absorption with chemical reaction. Adsorption types applications.

### Name of Text Books:

1. Unit Operation Chemical Engineering - McCabe & Smith

### Name of Reference Books:

1. Chemical Engineering Vol. I - Coulson J.M. & Richardson J.F.
2. Unit Operation - Brown & Associates.

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	Chemical Reaction Engineering-I	Subject Code	CL20612CL
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

### Unit-I

**Kinetics of Homogeneous Reactions:** Chemical kinetics; Rate theories; Rate expressions from mechanism & experiments.

**Classification of reactors:** Isothermal, Ideal batch, CSTR, PFR, Fixed beds, Moving beds, Non-ideal reactors, Fluidized beds, special types of reactors.

### Unit-II

**Interpretation of Batch Reactor Data:** Constant-volume batch reactor -Irreversible reaction, Reversible reaction; Analysis of rate of reaction; Differential method; Integral method; Least square method; Half life method; Initial value; Constant volume method reaction; variable volume method reaction; total pressure method; liquid phase reaction; analysis of complex reaction: series, parallel, auto catalytic. Varying-volume batch reactor

### Unit-III

**Design for Single reactions:** Size comparison of single reactors, multiple-reactor systems, Recycle reactor, Autocatalytic reactions

### Unit-IV

**Design for Single, Parallel and series reactions:** Irreversible reactions in parallel- Qualitative and quantitative discussion about product distribution, Irreversible Reactions in series- Qualitative and quantitative discussion about product distribution, Reversible reactions in series and parallel, Irreversible series-parallel reactions.

### Unit-V

**Temperature and Pressure Effects:** Single reaction, general graphical design procedure, optimum temperature progression, heat effects- adiabatic and nonadiabatic operations, Van Heerden relationship. Multiple reaction: Temperature and vessel size for maximum production.

### Name of Text Books:

1. Chemical Engineering Kinetics. J.M. Smith.
2. Chemical Reaction Engineering. Octave Levenspiel.

### Name of Reference Books:

1. Chemical Reaction Engineering. H.Scott Fogler.
2. Principles of Reaction Engineering, Central Techno Publications. S.D. Dawande.
3. Chemical Engineering, Volume IV. Coulson and Richardson.

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	<b>Transport Phenomena</b>	Subject Code	<b>CL20613CL</b>
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

### Unit-I

**Viscosity, Thermal conductivity, Diffusivity and the mechanisms of transport:** Newton's law of viscosity, Pressure and temperature dependence of viscosity, Molecular theory of the viscosity of gases at low density. and the mechanisms of energy: Fourier's law of heat conduction, Temperature and pressure dependence of thermal conductivity, Theory of thermal conductivity of gases at low density. Fick's law of binary diffusion, Temperature and pressure dependence of diffusivities, Theory of diffusion in gases at low density.

### Unit-II

**Shell momentum balances, energy balances and mass balances:** *Velocity distributions in laminar flow:* Shell momentum balances and boundary conditions, Flow of a falling film, Flow through a circular tube, Flow through an annulus, Flow of two adjacent immiscible fluids. *Temperature distributions in solids and laminar flow transport:* Shell energy balances; boundary conditions, Heat conduction with an electrical heat source, Heat conduction with a viscous heat source, Heat conduction with a chemical heat source, Heat conduction through composite walls, Heat conduction in a cooling fin, Forced convection and free convection. *Concentration distributions in solids and laminar flow:* Shell mass balances; boundary conditions, Diffusion through a stagnant gas film, Diffusion with a heterogeneous chemical reaction, Diffusion with a homogeneous chemical reaction, Diffusion into a falling Liquid film

### Unit-III

**The equations of change for isothermal systems:** The equation of continuity, The equation of motion, The equation of mechanical energy, Equation of energy and equation of continuity for binary mixture. Equations of change in curvilinear coordinates, Use of the equations of change to solve flow problems.

### Unit-IV

**Turbulent flow:** Basic theory of turbulence, time averaging, intensity and correlation coefficients, isotropic turbulence, equation of continuity, motion and energy for turbulent condition. Reynolds stresses.

### Unit-V

Application of transport equation through computations fluid dynamics (CFD): Basis of CFD, flow domain, grid generation, choice of suitable grid: structured or unstructured, finite difference and finite volume methods and approximations employed to solve the differential equations. Case studies for solving these equation for various chemical problems.

### Name of Text Books:

1. B. R. Bird, W. Stewart and E. N. Lightfoot, Transport Phenomena, Wiley, New York, 1960
2. L. Stuart et al., Transport Phenomena, John Wiley, New York, 1982. Name of Reference Books:
3. C. J. Geankopolis, Transport Processes in Chemical Operations, 3rd Ed., Prentice Hall of India, New Delhi, 1996.

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	Process Equipment Design-I (Mechanical Aspects)	Subject Code	<b>CL20614CL</b>
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

### **Unit-I**

General design considerations, Loads, Stresses, Welding and joint efficiency, Factor of safety, Corrosion allowance, Theories of failure, Compensation for opening in the vessel design, Fabrication methods.

### **Unit-II**

Design of storage vessel – Bottom, Shell and roof design, IS Codes

### **Unit-III**

Design of internal and external pressure vessel, Design of heads & closures (Torrispherical head, Hemispherical heads, Elliptical head, Conical head)

### **Unit-IV**

Design of tall vertical vessel,

### **Unit-V**

Design of flanges, Design of supports (Skirt support, Bracket support, Lug supports, Saddle supports)

### **Name of Text Books :**

1. M.V.Joshi, Process Equipment Design, McMillan Co..
2. Bhattacharya B.C., Introduction to Chemical Equipment Design Mech Aspects, CBS Publication.
3. IS Code – 2825 for unfired pressure vessel
4. IS Code – 803 for material specification, storage vessel

### **Name of Reference Books:**

1. Perry J.H., Chemical Engineers Hand book, McGraw-Hill, New York.
1. Molyneux F., Chemical Plant Design- Vol. I, Butterworth, Washington
2. Brown L.E. and Young E.H., Process Equipment Design, Wiley Eastern Ltd., New Delhi..
3. Dawande S.D., Process Design of Equipment, Central Techno Publications, Nagpur.

**NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR**  
**CHEMICAL ENGINEERING DEPARTMENT**

Name of Subject	<b>Organic Process &amp; Technology</b>	Subject Code	<b>CL20615CL</b>
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

**Unit-I**

**Esterification:** by organic acids, operation of esterification column. Technology of – oil, fat and waxes, soap and detergents.

**Unit-II**

**Sulfonation and sulfation:** Agents, principles, equipments. Technology – (i) Pulp and Paper, sugar, starch & glucose.

**Unit-III**

**Nitration:** Nitrating agents, liquid and vapor phase nitrations, process Equipments, mixed acid preparations. Technology – Dyes and intermediates.

**Unit-IV**

**Halogenation:** Type of halogenations reactions, halogenating agents. Technology – Pesticides and insecticides.

**Unit-V**

Polymerization engineering properties of polymers. Technology – Nylon, Terylene, Decron, viscous rayon, acetate rayon, thermosetting and thermoplastics, natural and synthetic rubber with specific consideration on vulcanization and reclaiming of rubber.

**Name of Text books:**

1. Grogging P.H., Unit processes in organic synthesis
2. Shreve R.N., Austin G.T., Chemical Process Industries

**Name of Reference books:**

1. M Gopala Rao Dryden's Outlines of Chemical Technology
2. Engineering – P. Chattopadhyay, Unit Operations of Chemical Engineering.
3. Dawande S.D., Introduction to Polymer Science & Technology, Central Techno Publications.

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	Non-Conventional energy Sources (elective-1)	Subject Code	CL20616CL
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

### Unit-I

Environmental Aspects of Power Generation, Heat Transfer for Solar Energy, Utilization Flat Plate Collectors: Physical principles of conversion of solar radiation into heat, Thermal losses and efficiency of FPC, Practical considerations for flat plate collectors, Applications of FPC – Water heating and drying. Focusing Type Collectors: Orientation and sun tracking systems, Types of concentrating collectors – Cylindrical parabolic collector, Compound parabolic collector, Thermal performance of focusing collectors, Testing of solar collectors.

### Unit-II

Solar cooking, solar desalination, solar ponds and solar space heating Solar Industrial process heating and Solar power generation. Solar Green Houses, Solar thermo mechanical power, solar refrigeration & air conditioning and Solar High Temperature Applications Gasifier-Classification, Chemistry, Application, advantages, disadvantages and application.

### Unit-III

Energy from Biomass: Type of biomass sources, biomass generation, factors affecting biodigestion, classification, advantages and disadvantages of biogas plants, community biogas plants, problems related to biogas plants, utilization of biogas. Energy plantation, methods for obtaining energy from biomass, thermal gasification of biomass.

### Unit-IV

Chemical Energy Sources: Fuel cells: Design, principle, classification, types, advantages and disadvantages Hydrogen Energy: Properties of hydrogen, methods of hydrogen production, physical and chemical principles, storage, advantages and application

### Unit-V

Wind Energy: Basic principle, wind energy conversion, wind energy conversion systems, design consideration, performance and application. Alcohol fuels: Overview, feedstock, methods for alcohol production, alcohol as an engine fuel; LPG, CNG Hydrogen and Ethanol as an alternative liquid fuel; engine performance with alcohol fuels. Tidal Energy.

### Name of Text Books:

1. John A Duffie & William A Beckman: Solar Energy Thermal processes Wiley Inter science publication
2. H P Garg & J Prakash, Solar Energy – Fundamentals and Applications: - Wiley Inter science

### Name of Reference Books:

1. G D Rai, Solar Energy Utilization – Khanna publishers.
2. S P Sukhatme, Solar Energy – Principles of thermal Collection & Storage – Tata McGraw Hill Publishing company ltd., New Delh.

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	<b>Pulp &amp; paper Technology</b>	Subject Code	<b>CL20617CL</b>
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

### Unit-I

Pulping: Kraft Pulping – Introduction, Overview of Pulping Operation, Digesters, batch and continuous, direct and indirect heating, reaction kinetics, H-factor, transport phenomena during pulping. G factor, extended delignification, rapid displacement heating (RDH), blow heat recovery.

Washing – Introduction, Transport Phenomena during washing – diffusion vs. displacement, single and multistage washing, counter current rotary drum washers, dilution factor, displacement ratio, washing capacity and efficiency, soda loss, material and flow balances for systems with recycle.

### Unit-II

Screening and Cleaning – Introduction, Objectives and Theory, Screening system process design, Centrifugal Cleaners – forward and reverse cleaners, principles of operation, drag vs centrifugal force, design and operation parameters, screening and cleaning efficiency for multistage systems, material and flow balances for systems with recycle.

Bleaching – Transport phenomena during bleaching, mixers, pumps, bleach tower design and operation, up flow vs down flow towers, washing after bleaching.

### Unit-III

Chemical Recovery – Kraft Recovery Process, Introduction, Overview of Kraft recovery, recovery cycle, properties of black liquor – composition, density or specific gravity, total solids, viscosity, thermal conductivity, specific heat, boiling point, boiling point rise (BPR), heating value – higher and lower heating value; evaporation, process requirements, single effect and multiple effect evaporators (MEE) mass and energy balances in MEE, multiple effect analysis – capacity, steam economy. Vapor Recompression Evaporators. Scaling and Scale Control.

### Unit-IV

Chemical Recovery – Black Liquor combustion – basic process steps – drying, pyrolysis, char combustion. Particle entrainment, recovery boiler equipment – furnace, liquor spray, combustion air system, smelt. Convective Heat transfer, boiler capacity, mass and energy balances.

Chemical Recovery – Slaking and Causticizing, Causticizing rates. Separation processes – sedimentation, filtration, separation variables, clarifier design and operation, material balances, lime reburning, calcining lime mud, rotary lime kiln, mass and energy balances, fluidized bed calciners.

### Unit-V

Stock preparation, Additives, conversion of pulp to paper.

Name of Text Books

Pulp and Paper, 3<sup>rd</sup> edition Vol I, II, III and IV Wiley International New York.

Hand book of Pulp and Paper Technology, Vannostrand New York.

Name of Reference books.

1. G. N. Pandey , Chemical Tech. Vol II.
2. Dryden , Outlines of Chemical Tech.

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	<b>Membrane separation</b>	Subject Code	<b>CL20618CL</b>
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	70	Minimum marks	25
Lecture period works	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Details of Course:

### Unit I

Principles of membrane separation, Types of membranes, membrane processes classification, characterization and preparation of membranes.

### Unit II

Analysis and modelling of of membrane separation, membrane modules and applications. Transport Theory in membranes – porous membrane, bulk flow, liquid diffusion in pores, Gas Diffusion.

### Unit III

Non-Porous Membranes – solution diffusion for liquid mixtures and gas mixtures, module flow patterns, control, polarization and fouling. Metal membranes and ceramic membranes.

### Unit IV

Dialysis and Electro dialysis, Reverse osmosis – membrane materials-sea water and brackish water Desalination membranes. Nanofiltration, Gas permeation.

### Unit V

Per Vaporation, ultrafiltration, Microfiltration, Constant-flux operation, constant pressure operation. Combined operation and Industrial application.

### Textbooks

Separation Process by King. J McGraw – Hill

Separation Process Principles by – J.D. Seader / Ernest J. Henley.

Member Technology and Applications - Richard w. Baker.



# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	<b>Mass Transfer Lab</b>	Subject Code	<b>CL20621CL</b>
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	20	Minimum marks	10
		Practical Periods/Week	Credits
		3	2

Details of Course:

### List of experiments

1. To study the VLE of binary mixtures
2. Determination of the diffusion co-efficient of an organic vapour in air.
3. To study the performance of a Swanson Walker Crystallizer and to determine the crystal yield and the efficiency of crystallizer.
4. To estimate the batch curves for a binary system and verify the binary distillation equation for a known number of theoretical plates and To operate the column under total reflux condition and estimate the minimum number of theoretical plates required.
5. To study the drying characteristics of a solid under forced draft condition and determine the critical moisture content.
6. To study the kinetics of dissolution of Benzoic acid in water.
7. To determine the liquid-liquid equilibrium for a system of three liquids with one pair only partially soluble
8. Extraction of sodium carbonate from solid mixture of sand and sodium carbonate with water as solvent using simple single contact
9. To study the kinetics of homogeneous liquid-liquid mass transfer limited chemical reactions
10. To determine the gas film coefficient in a wetted wall column using air-water system.
11. Actual visualization of the cooling tower operation and to determine the mass transfer coefficient

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	Organic Process Technology Lab.	Subject Code	CL20622CL
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	20	Minimum marks	10
		Practical Periods/Week	Credits
		3	2

### Details of Course:

Experiments to be performed: (Minimum 10)

1. To determine the Acid Value of given oil sample
2. To determine the Saponification value of given oil sample
3. To determine the % of total fatty material present in given soap.
4. To determine the free alkali content in given soap sample.
5. To determine the Moisture content of the given soap sample
6. To determine the Esterification Value of the given oil sample.
7. Preparation of phenol-Formaldehyde Resin
8. To determine the Iodine value of the given oil sample.
9. Manufacture of Toilet soap
10. Manufacture of Detergent.
11. Manufacture of Phenyl.
12. Manufacture of Paint.
13. Solvent Extraction of oil from oilseed in Soxhlet apparatus.
14. To determine the % of oil in given oil bearing seed sample.
15. Esterification of given sample & determination of % esterification achieved.

### List of Equipments/Machines Required

1. Soxhlet apparatus
2. Oven
3. Weighing Balance
4. Hot Plate
5. Water bath
6. Agitator
7. Distillation Unit

### Recommended Books:

1. Groggings P.H., Unit process in organic synthesis
2. Shreve. G T Austin, Chemical Process Industries.
3. M Gopala Rao, Dryden's Outlines of Chemical Technology
4. Chattopadhyay P., Unit Operations of Chemical Engg.

# NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR

## CHEMICAL ENGINEERING DEPARTMENT

Name of Subject	Chemical Reaction Engg. Lab	Subject Code	<b>CL20623CL</b>
Semester	B. Tech. – 6 <sup>th</sup> Semester	Board of Studies	Chemical Engg.
Maximum Marks	20	Minimum marks	10
		Practical Periods/Week	Credits
		3	2

Details of Course:

### List of experiments

1. To study physical dissolution of benzoic acid on water in Batch Reactor.
2. To Study of a Non-Catalytic Homogeneous reaction in an Isothermal Batch Reactor.
3. To study of a non-catalytic homogeneous reaction in a Straight type plug flow reactor under ambient conditions.
4. To study Residence Time Distribution (RTD) in a CSTR.
5. To study a non catalytic homogeneous second order liquid phase reaction in a CSTR
6. To study a non catalytic homogeneous reaction in a packed bed.