NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF CHEMICAL AND TEXTILE ENGINEERING

CHEMICAL ENGINEERING PROGRAM

PI144 – MASS TRANSFER I

I. GENERAL INFORMATION

CODE	**:**	PI144 – Mass Transfer I
SEMESTER	**:**	8
CREDITS	**:**	3
HOURS PER WEEK	**:**	4 (Theory–Practice)
PREREQUISITES	**:**	PI142 Momentum Transfer
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Chemical Engineering

II. COURSE DESCRIPTION

The course prepares students for understanding and applying the principles of mass transfer processes. Students understand molecular diffusion principles and apply Flick First Law for determining total and individual coefficients. Students also apply proper methods for designing multi-stage distillation columns, as well as understand the process for liquid-liquid extraction and solid-liquid extraction. Students formulate models for the processes and analyze their behavior and outcomes, as well as carry out experimental work in the Laboratory of Unit Operations. Industrial applications of mass transfer process are analyzed.

III. COURSE OUTCOMES

At the end of the course, students:

1. Understand and explain the principles of molecular diffusion and separation process.
2. Understand and apply Flick First Law for describing diffusion processes under steady state conditions.
3. Understand interphase mass transfer processes and determine total and individual coefficients.
4. Design plate columns for gaseous phase dispersing satisfying requirements and constraints.
5. Design of multi-stage distillation columns using Ponchont-Savarit method and Mcabe-Thiele method
6. Understand and describe the processes for liquid-liquid extraction and solid-liquid extraction.

IV. LEARNING UNITS

1. INTRODUCTION AND MOLECULAR DIFFUSION

Introduction / Separation unit operations: absorption, desorption, distillation, liquid-liquid extraction, solid-liquid extraction, drying, humidifying, etc. / Election of separation method / Mass transfer. Fick First Law / Steady state molecular diffusion in static fluids and laminar flows / Gas molecular diffusion / Liquid molecular diffusion / Diffusivity calculation / Multicomponent diffusivity.

2. MASS TRANSFER COEFFICIENT

Computation of mass transfer flux / Methods for determining the coefficient of mass transfer process / Analogy between mass transfer, heat transfer and momentum transfer / Mass transfer correlation for different geometries. Mass transfer from spheres (drops)

3. INTERPHASE MASS TRANSFER

Phase equilibrium / Controlling resistance / Interface concentration / Mass transfer total coefficients / Relationship between total and individual coefficients / Mass balance.

4. DESIGN OF MASS TRANSFER EQUIPMENT

Types of equipment / Gaseous phase dispersing equipment / Tanks / Plate columns, design considerations bell plates, perforated plates/ valve plates / Liquid phase dispersing equipment / Design of fill columns / Typical problems in fill columns.

5. GASEOUS ABSORPTION

Liquid-gas equilibrium / Mass balance in an absorption column (desorption) / Equation of operation line / Plate tower / Calculation of required number of plates / Minimum fluid flow.

6. DISTILLATION

Binary distillation / Liquid-vapor equilibrium / Ideal solutions / Raoult Law / Relative volatility / Ebullition diagram / Flash distillation / Partial condensation / Design of multi-stage distillation columns / Ponchont-Savarit method: Mass and energy balance, Difference points placement, Partial and total superheater and condenser, Feeder thermal condition, Minimum reflow, Optimal reflow, Multiple feeders, Lateral currents / Mcabe-Thiele method: Mass balance, Operation line equation, Feeding thermal condition, Total and partial condensers / Azeotropic distillation / Extractive distillation.

7. LIQUID-LIQUID EXTRACTION

Uses of liquid-liquid extraction / Liquid-liquid equilibrium / Triangular diagrams / Free solvent base diagrams / Distribution curves / Solvent selection / Solvent recovery / Design: simple contact, crossed currents, countercurrents, extraction with reflow / Packed tower / Liquid-liquid extraction in immiscible systems.

8. SOLID-LIQUID EXTRACTION

Introduction / Lixiviation processes / Lixiviation equipment / Solid preparation for lixiviation / Equilibrium relationships / Graphics / Triangle-rectangle diagrams / Free solvent base diagram / Constant solvent flow / Constant solution flow / One-step lixiviation / Multiple steps lixiviation / Parallel currents lixiviation / Countercurrent lixiviation.

V. LABORATORY AND PRACTICE WORK

Session 1: Fick First Law.
Session 2: Gaseous phase dispersing tanks.
Session 3: Design of multi-stage distillation column.
Session 4: Liquid-liquid extraction – Packed tower.
Session 5: Solid-liquid extraction. Constant solvent flow.

VI. METHODOLOGY

The course takes place in theory, practice and laboratory sessions. In theory, faculty presents and analyzes concepts and methods. In practice sessions diverse problems related to mass transfer in distillation, liquid-liquid extraction, solid-liquid extraction processes are solved and analyzed, as well as their application in actual industrial plants. In laboratory sessions, students perform tests and verify expected outcomes and results. After each laboratory experience, students submit a report describing procedures and summarizing results and conclusions. Student active participation is promoted.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + EF + 2*PP) / 4

EP: Mid-term Exam   EF: Final Exam
PP: Average of Practical and Experimental Works

VIII. BIBLIOGRAPHY

1. **HINNES Maddox**
   Mass Transfer: Fundamentals and Applications. Prentice Hall Editions, 2004.
2. **KING Hudson**
   Separation Process Principles. Reverte Editions, 2008.