# NATIONAL UNIVERSITY OF ENGINEERING
## COLLEGE OF PETROLEUM AND PETROCHEMICAL ENGINEERING
## PETROCHEMICAL ENGINEERING PROGRAM

# PQ423 – MASS TRANSFER

## I. GENERAL INFORMATION

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|---|---|---|
| **CODE** | : | PQ423 – Mass Transfer |
| **SEMESTER** | : | 8 |
| **CREDITS** | : | 3 |
| **HOURS PER WEEK** | : | 4 (Theory–Practice) |
| **PREREQUISITES** | : | PQ413 Momentum Transfer, PQ414 Heat Transfer |
| **CONDITION** | : | Compulsory |

## II. COURSE DESCRIPTION

This course prepares students for the analysis of advanced mas transferring processes such as multicomponent and vapor drag distillation, absorption, humidification and dehumidification, drying, membrane separation and adsorption. 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 apply concepts and operating techniques of mass transfer in industrial processes.
2. Analyze mass transfer processes such as multicomponent and vapor drag distillation, absorption, adsorption, humidification and dehumidification, drying and membrane separation.
3. Formulate models of the process of mass transfer.
4. Use semi-industrial equipment, similar to the actual industry.
5. Calculate and analyze the efficiency of mass transfer operations.
6. Complete research projects following the scientific method.

## IV. LEARNING UNITS

### 1. MULTICOMPONENT DISTILLATION

Introduction / Liquid–Vapor equilibrium in binary systems and the extension to multicomponent systems / Election of the light clave and heavy clave / Design calculations / Shortcut method / Product composition / Minimum relation of reflow / Minimum number of plates / Number of ideal stages / Source plate localization.

### 2. DISTILLATION BY VAPOR DRAG

Conceptual base for distillation by vapor drag / Hausbrand diagrams / Liquid–Vapor equilibrium of immiscible substances / Industrial applications / Essential oils and vegetal products / Extraction operations of essential oil by vapor drag.

### 3. NON-ISOTHERMAL ABSORPTION

Introduction / Non-isothermal absorption: adiabatic absorption and desorption / Heat of solution effects / Concentration effects / Gas-liquid equilibrium / Design calculations / Industrial applications and environmental protection.

### 4. HUMIDIFICATION AND DEHUMIDIFICATION

Introduction / Basic definitions / Absolute humidity / Saturation curve / Dew temperature / Humid heat / Enthalpy / Equipment for humidification and dehumidification / Cooling towers. Types / Equipment description / Cooling tower / Tower height / Calculation of temperature of exit gases / Design of a dehumidifier tower / Problems related to humidifiers and dehumidifiers.

**5. MEMBRANE SEPARATION, INVERSE OSMOSIS**

Membrane processing / Advantages of membrane separation / Membrane definition / Membrane materials / Membrane modulus / Membrane transport / Gases diffusion / Liquid mixtures diffusion / Diffusion for gas mixtures / Permeation of gas and liquids by membranes / Concentration and pressure effects / Temperature effects / Inverse osmosis mechanism / Design / Applications.

**6. DRYING**

Basic definitions / Free humidity and equilibrium / Equipment for drying: tray dryer, tunnel dryer, rotatory dryer, atomization dryer / Drying speed curves: experimental methods / Drying curves / Constant drying speed / Decreasing drying speed / Calculation methods / Modeling equations of diverse types of dryers / Tray dryer for variable air conditions / Mass and energy balance for continuous dryers.

**7. ADSORPTION**

Introduction / Operation basic concepts / Utility as separation technique / Adsorbent material: activated alumina, activated carbon, gel silica, magnesium oxide / Processes analysis / Liquid and gas adsorption / Adsorbent fluid equilibrium / Isothermal adsorption / Isothermal of Freundlich and Langmuir / Other models / Experimental data interpretation.

## V. LABORATORY

**Session 1:** Multicomponent systems calculation and simulation.
**Session 2:** Distillation by vapor drag for essential oils extraction.
**Session 3:** $CO_2$ absorption in solutions of sodium hydroxide.
**Session 4:** Solvents recovery from air flows for cooling.
**Session 5:** Efficiency of a plant of water treatment by inverse osmosis.
**Session 6:** Materials drying.
**Session 7:** Effluent depolluting by activated carbon absorption.

## 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, absorption and adsorption, drying and membrane separation 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. TREBAL, ROBERT.
   Mass Transfer Operation, McGraw-Hill, 2005.
2. SEADER, J.D. HENLEY, E.J.
   Separation Process Principles, John Wiley & Sons, Inc., 2006.
3. SCHWEITZER, P.A.
   Handbook of Separation Techniques for Chemical Engineering, Mc-Graw-Hill Book Co., 2009.