# NATIONAL UNIVERSITY OF ENGINEERING
# COLLEGE OF CHEMICAL AND TEXTILE ENGINEERING

## TEXTILE ENGINEERING PROGRAM

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# PI140 – TRANSPORT PHENOMENA

## I. GENERAL INFORMATION

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| **CODE** | : | PI140 – Transport Phenomena |
| **SEMESTER** | : | 7 |
| **CREDITS** | : | 3 |
| **HOURS PER WEEK** | : | 4 (Theory–Practice) |
| **PREREQUISITES** | : | MA143 Mathematics IV, PI111 Mass and Energy Balance. |
| **CONDITION** | : | Compulsory |
| **DEPARTMENT** | : | Chemical Engineering |

## II. COURSE DESCRIPTION

The course prepares students in the analysis of momentum, heat and mass transport phenomena in order to explain the transformations occurring in chemical and petrochemical processes. The analysis is based on momentum, heat and mass balances considering molecular transport scale, and turbulent transport.

## III. COURSE OUTCOMES

At the end of the course, students:

1. Understand the basic laws of transport phenomena: Fourier law, Fick law and Newton law for analyzing the transport of heat, mass and momentum, and their interrelations.
2. Apply basic laws of physics, chemistry and engineering in momentum, mass and energy balance, taking as reference a control volume, and using and solving proper equations.
3. Solve problems related to momentum, energy and mass transport in stationary and non-stationary conditions.

## IV. LEARNING UNITS

**1. INTRODUCTION TO TRANSPORT PHENOMENA**

Introduction / Unit Process / Unit operation / System of measurement units: International System of Measures, CGS and English System of Units / Examples / Analogy of transport phenomena in molecular transport / Fourier's law / Fick law / Newton law of viscosity / Reynolds number and viscosity / Newtonian and non-Newtonian fluids / Molecular transport mechanisms / Fundamentals of transport phenomena / Calculations.

**2. PROPERTIES OF TRANSPORTATION: CONDUCTIVITY, DIFFUSIVITY AND VISCOSITY**

Calculation of transport properties: thermal conductivity, thermal diffusivity and viscosity / Viscosity of Newtonian and non-Newtonian fluids. / Thermal conductivity and thermal diffusivity / Calculation methods.

**3. HEAT IN COMPOUND WALLS**

Application of driving force and resistance in compound walls in heat transfer processes / Thermal resistance in a flat plate, a hollow cylinder, and a hollow sphere / Average logarithmic area and average geometric area / Application of energy balance and Fourier law to analyze heat flow in compound walls / Flow heat in series and parallel compound walls / Heat with variable thermal conductivity / Convection / Determination of the overall coefficient of heat transfer in flat plates and coaxial cylinders.

**4. APPLICATION OF ENERGY BALANCE AND FOURIER LAW TO DETERMINATE TEMPERATURE GRADIENTS**

Application of energy balance and Fourier law / Differential equation of one-way heat conduction in rectangular, cylindrical and spherical coordinates for the determination heat and temperature gradients / Application of heat transfer in stationary state, with and without generation / Modeling.

5. **APPLICATION OF MOMENTUM BALANCE AND NEWTON LAW TO DETERMINATE VELOCITY GRADIENTS**
   Application of momentum balance and Newton's law in stationary state / Analysis of forces that allow the movement of fluids: gravitational force, force due to pressure, viscous forces / Determination of shear stress and speed gradients, maximum speed, flow and average speed / Relationship of shear stress and the speed gradients / Modeling.

6. **APPLICATION OF MASS BALANCE AND FICK LAW TO DETERMINATE THE CONCENTRATION GRADIENT**
   Application of mass balance and Fick law in stationary state / Models without chemical reaction / Models with diffusion with chemical reaction for the determination of concentration gradient, pressure and molar fraction, as well as mass flow / Modeling.

7. **BIDIRECTIONAL HEAT TRANSFER IN STABLE STATE, AND ONE-WAY TRANSFER IN UNSTABLE STATE**
   Two-directional heat transfer in stable state / Application of the finite difference numerical method to compute temperature and heat by the mesh method / Heat conduction in unstable state, application of numerical method for finite difference to compute temperature gradients and heat.

8. **DIFFUSION IN BINARY MIXTURES WITH CONVECTION**
   Diffusion of gases with convection, in constant areas and without chemical reaction / Diffusion of gases with convection, variable area and without chemical reaction / Models of calculation to determine the time of evaporation or sublimation of substances by diffusion / Application of mass balance and diffusion in binary mixtures, with convection, to determinate concentration gradients / Diffusion with convection and chemical reaction in constant and variable area.

9. **EQUATIONS FOR VARIATION. CONTINUITY EQUATION AND EQUATION OF MOTION**
   Continuity equation in spherical, cylindrical and rectangular coordinate systems / Equation of motion in rectangular, cylindrical and spherical coordinate systems / Equation of Navier-Stokes / Solution of problems related to Newtonian fluids / Applications of the equations of variation: viscometer of Couette, viscometer of Ostwald and viscometer of cone and plate / Application of equations in non-Newtonian fluids / Bingham model / The power law model.

10. **TURBULENCE TYPES**
    Turbulence and transport phenomena / Differences with molecular transport / Equations of Van Karman for speed distributions.

## V. METHODOLOGY

The course takes place in theory and practice sessions. In theory sessions, faculty presents the concepts, principles, laws and methods. In practice sessions, students solve diverse problems related to heat, momentum and mass transport in engineering applications, using computer software. At the end of the course, students submit and defend a final report. Student active participation is promoted, as well as continuous bibliography search and analysis.

## VI. GRADING FORMULA

The Final Grade PF is calculated as follow:

**PF = (EP + EF + PP) / 3**

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

## VII. BIBLIOGRAPHY


1. R.B. BIRD, W.E. STEWARD, E.N. LIGHTFOOT.
   Transport Phenomena. 2nd Edition. Ed. Limusa Willey, 2007.
2. J.R. WELTY, C.E. WICKS.
   Fundamentals of Momentum, Mass and Heat Transfer. Ed. Limusa Willey, 2008.