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

PQ413 – MOMENTUM TRANSFER

I. GENERAL INFORMATION

CODE	:	PQ413 – Momentum Transfer
SEMESTER	:	7
CREDITS	:	3
HOURS PER WEEK	:	4 (Theory–Practice)
PREREQUISITES	:	PQ323 Transport Phenomena
CONDITION	:	Compulsory

II. COURSE DESCRIPTION

The course prepares students in the concepts, principles and mechanisms of momentum transfer in fluids motion, analyzing the forces that produce the motion in different regimens and working conditions. Students analyze Newtonian and non-Newtonian fluids, compressible and uncompressible fluids, laminar and turbulent flows, one-phase and two-phase flows, flow in pipes and ducts, flow in pumping systems, as well as fluids stirring and mixing processes.

III. COURSE OUTCOMES

At the end of the course, students:

1. Understand the fundamentals of fluid mechanics.
2. Understand and apply the equations of piping design for liquid and gas fluids.
3. Know the characteristics of different types of pumps, their functioning, selection and design considerations.
4. Understand the mechanism of filtration technology and the equations for the design of industrial equipment
5. Plan the design of pipes in an industrial chemical plant.

IV. LEARNING UNITS

1. **FLUID BEHAVIOR**
   Shear stress / Viscosity / Newtonian and non-newtonian fluids / Momentum flows / Systems and volume control / General equations of balance.
2. **MASS BALANCE**
   Integral continuity equations / Mass balance in reactive processes.
3. **ENERGY BALANCE**
   Integral equations of energy / Special cases / Application problems.
4. **MOMENTUM BALANCE**
   Integral equations of momentum I / Special cases / Integral equations of momentum II / Pelton and Francis turbines.
5. **FLOWS SIMILARITY**
   Geometric, kinetic and dynamic similarity / Non-dimensional numbers / Modeling / Examples.
6. **LIMIT LAYER THEORY**
   Ideal fluids / Limit layer thickness / Drag and sustentation forces / Special cases.
7. **TURBULENCE**
   Average velocities / Fluctuations / Apparent tension and viscosity of turbulence / Reynolds stress / Velocities distribution and shear stress.
8. **FLOWS IN PIPES AND DUCTS**

Critical Reynolds numbers / Hydraulic radius / Entrance conditions / Distribution of speeds and shear stresses in laminar and turbulent flows, and smooth and rough pipes / Calculation of pressure loses / Friction factor: formulas and graphics / Minor losses / Problems of sizing of pipes / Flow in piping design / Calculation of flows parameters and variables / Flow in series, parallel, and branching pipes / Moody chart, nomograms and software for calculation of pressure losses.

9. **PUMPS**
Centrifugal pumps / Curves / Characteristics / Efficiency / Power / NPSH estimation / Specifications / Pumps in series and parallel configurations.
10. **FLOW MEASUREMENT**
Basic considerations about statics of fluids / Pitot theory / Measurement instruments: Venturi, hole, rotameters and others. / Calculation and sizing.
11. **COMPRESSIBLE FLOW**
Integral equation of compressible flows / Compressors: Isothermal and adiabatic / Calculation of the number of stages
12. **BIPHASIC FLOW**
Biphasic flow, gas–liquid / Types and models of stationary and uni-dimensional flows / Pressure losses / Solid fluid / Model of two phases flow / Fluidization / Non-stationary flow in particle dispersion.
13. **MOMENTUM TRANSFER SPECIAL SITUATIONS**
Pressure losses in packed towers / Carman– Kozeny equation / Filtration: general equations / Calculation and operating methods.
14. **LIQUIDS STIRRING AND MIXING**
Types of flow / Stirrer types / Number of power / Power consumption.

V. LABORATORY AND PRACTICAL WORK

Session 1: Mass balance.
Session 2: Energy balance.
Session 3: Momentum I and II.
Session 4: Flow in pipes.
Session 5: Pumps.
Session 6: Filtration and stirring

VI. METHODOLOGY

The course takes place in theory, practice and laboratory sessions. In theory, faculty presents and analyzes concepts, principles and methods. In practice sessions diverse problems related to momentum transfer, flow in pies and ducts, laminar and turbulent flows, compressible flow, two-phase flows and liquid stirring and mixing are solved, 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 + PP) / 3

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

VIII. BIBLIOGRAPHY

1. STREETER Victor L.
Fluid Mechanics, Mc Graw Hill, 2005.
2. MATAIX Claudio
Fluid Mechanics and Hydraulic Machines, 2008
3. WELTY James, WIKS R.E.
Fundamentals of Momentum, Heat and Mass Transfer, Limusa Ed., 2008