NATIONAL UNIVERSITY OF ENGINEERING

COLLEGE OF PETROLEUM AND PETROCHEMICAL ENGINEERING

PETROCHEMICAL ENGINEERING PROGRAM

PQ414 – HEAT TRANSFER

I. GENERAL INFORMATION

CODE	**:**	PQ414 Heat Transfer
SEMESTER	**:**	7
CREDITS	**:**	4
HOURS PER WEEK	**:**	4 (Theory–Practice)
PREREQUISITES	**:**	PQ323 Transport Phenomena
CONDITION	**:**	Compulsory

II. COURSE DESCRIPTION

The course prepares students in the understanding and application of heat transfer processes in mechanical and thermal systems. Students understand the mechanisms of heat transfer, fundamental equations, heat transfer in flat and curved walls, heat with extended surfaces, radiant exchange between surfaces, and natural and forced convection. Students complete the design of a heat exchanger satisfying given requirements and constraints.

III. COURSE OUTCOMES

At the end of the course, students:

1. Explain the forms of heat transfer and represent them by mathematical expressions.
2. Solve specific problems related to heat transfer in electromechanical systems, and perform an appropriate numerical calculation.
3. Explain the process of conductive, convective and radiant heat transfer and compute their variables for given conditions.
4. Understand the process of heat transfer with phase change (evaporation and condensation).
5. Design heat exchangers (cooling towers and evaporators) for different requirements, applying proper techniques.

IV. LEARNING UNITS

1. INTRODUCTION TO HEAT TRANSFER MECHANISMS

Modes of heat transfer / Conduction, convection, radiation and multi-mode heat transfer / One-way conduction systems in permanent status / Critic radius of insulation Application problems.

2. STATIONARY STATE CONDUCTION

Heat transfer differential equation / One-way conduction: systems with internal generation of heat, extended surfaces / Efficiencies of fins / Application problems / Two and three dimension systems: analytical, graphical and numerical solutions / Application problems.

3. MOLECULAR DIFFUSION IN PERMANENT STATE

Mass transfer differential equation / One dimension mass transfer independent of chemical reactions / Equi-molar counter-diffusion. / One dimension systems associated with chemical reaction / Application problems.

4. HEAT TRANSFER BY RADIATION

Heat radiation / Intensity of radiation / Law of Plank / Stefan-Boltzmann law / Emittance and absorbency of surfaces / Exchange of radiation (the factor of vision) / Exchange of heat between black surfaces by radiation / Volumetric gas radiation / Application problems.

5. **CONVECTIVE TRANSFER ANALYSIS**
   Exact analysis of the boundary layer on a flat wall / Thermal boundary layer / Concentration boundary layer / Approximate analysis of boundary layers / Analogy between transfer of momentum, energy and mass.

6. **HEAT CONVECTIVE TRANSFER**
   Considerations about turbulent flow / Forced convection in external flow: crossed flow on cylinders and spheres / Bank of pipelines / Internal flow in forced convection: thermal boundary layer / Energy balance / Laminar flow / Turbulent flow / Non-circular ducts / Void section / Natural convection: laminar analysis on a vertical wall / Effects of turbulence / Empirical outside correlations of forced and free convection / Boiling in forced convection / Condensation, laminar condensation on a vertical wall / Condensation on cylinders and on fields / Application problems.

7. **HEAT TRANSFER WITH PHASE CHANGE**
   Heat transfer in ebullition / Data correlation of heat transfer in ebullition / Heat transfer in condensation processes /

8. **HEAT TRANSFER EQUIPMENT**
   Heat exchanger / Thermal calculation of heat exchangers: Method of Average Logarithmic Difference of Temperatures (ALDT) / Number of Transfer Units Method. (NTU) / Cooling towers / Towers of continuous contact / Mass balance / Enthalpy balance / Capacity coefficients / Evaporators / Design of simple effect evaporators / Multiple effect evaporators / Natural circulation / Forced circulation / Application problems.

V. PRACTICAL EXPERIENCE

Session 1: Fundamentals of heat transfer.
Session 2: Heat transfer by conduction, convection and radiation.
Session 3: Convective heat transfer
Session 4: Heat transfer with phase change
Session 5: Design of cooling towers and evaporators.

VI. METHODOLOGY

The course takes place in theory and practice sessions. In theory sessions faculty presents the theory, concepts and methods. In practice sessions, students apply theory to solve diverse problems related to heat transfer in different engineering applications. Students also design a heat exchanger satisfying given requirements and constraints. At the end of the course, students submit and defend a final report. Student active participation is promoted throughout the course.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

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

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

VIII. BIBLIOGRAPHY

1. **INCROPERA, Frank**
   Fundamentals of Heat Transfer. 6th Edition, USA, 2007.
2. **KERN, Donald**
   Heat Transfer Processes, Mc. Graw–Hill Ed., 2005
3. **BIRD R. B.**
   Transport Phenomena. 2nd Edition, New York, 2012