ESIROI
ÉCOLE D'INGÉNIEURS
UNIVERSITÉ DE LA RÉUNION

DEPARTMENT : *CPI*
SEMESTER : *S4*

IDENTIFICATION

Course code : E2CP4PC1
ECTS : 4

DURATION

Lectures :	12
Tutorial classes :	12
Labs :	12
Total :	36

Project :
Personnal work :

ASSESSMENT

2 Written exams (2h/2h) + 1 Lab report

TEACHING MATERIALS

LANGUAGE

English

CONTACT

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UE : PHYSIQUE-CHIMIE

COURSE : Bilans and Transfers

SCOPE OF THE COURSE

OBJECTIVES

Study of open systems and balance physics

COMPETENCE AND SKILLS

- To be able to define the phenomenon of particle diffusion and convection.
- To be able to define the particle current density vector and the particle flux.
- To know Fick's law (with units) and its limitations.
- To know the method for performing balances for 1D diffusion.
- To know the local formulation of 3D diffusion as well as its integral formulation.
- To be able to demonstrate that diffusion is an irreversible phenomenon.
- To be able to solve the diffusion equation in steady-state 1D (Cartesian coordinates).
- To know the consequences of steady-state : conservation of flux.
- To know that, for time-dependent regimes, the form of the solution depends on the boundary conditions.
- To be able to derive characteristic quantities of diffusion from the equation.
- To be able to define the ARQS (quasi-static approximation).
- To know the general principle of osmosis.
- To know the three main modes of transfer : convection, conduction, and radiation, and their characteristics.
- To be able to define the heat flux and the thermal current density vector.
- To know Fourier's law (with units) and the meaning of its terms.
- To be able to derive the conservation equation and the 1D heat diffusion equation.
- To be able to generalize the equation to 3D ; to know the concept of thermal diffusivity and its unit.
- To recognize the link between particle diffusion and heat conduction.
- To be able to demonstrate the irreversibility of the phenomenon.
- To be able to derive the temperature profile and the entropy balance in the case of a 1D bar.
- To know the first law of thermodynamics (differential or power form).
- To be able to simplify it in steady-state ; to express it in mass-specific form.
- To be able to solve simple examples : Bernoulli's theorem, mixer with heating, heat exchangers, condenser, evaporator, turbine, nozzle, compressor.
- To know the industrial second law of thermodynamics.
- To be able to simplify it in steady-state ; to express it in mass-specific form.
- To know the example of Joule–Thomson expansion : energy and entropy balances (case of a perfect gas).

PROGRAM

1. **Methodology of balances** System identification, choice of reference frame, writing local and integrated balances, closure hypotheses.

2. **Thermal energy transfer** Conduction, convection, radiation ; heat flux, thermal current density, Fourier's law, thermal diffusion equations.
3. **Energy and entropy balances in open systems** First and second laws in steady or unsteady regimes, power and mass forms, irreversibility, entropy production.
4. **Mass balances** Mass conservation, scalar and vector balances, diffusion, convection, mass flux, Fick's law, 1D resolution.

BIBLIOGRAPHY

— D. Kondepudi, I. Prigogine, *Thermodynamics : From Heat Engines to Dissipative Structures*, Wiley.
— P. Colonna, S. van der Stappen, *Introduction to Thermodynamics*, TU Delft OpenCourseWare.
— F. Incropera, D. DeWitt et al., *Fundamentals of Heat and Mass Transfer*, Wiley.
— Y. Demirel, *Nonequilibrium Thermodynamics : Transport and Rate Processes in Physical, Chemical and Biological Systems*, Elsevier.
— J. Thome, *Engineering Heat Transfer*, EPFL Press.

REQUIREMENTS

— Basics of differentiation and integration.
— Elementary knowledge of thermodynamics (1st and 2nd laws).
— Basic concepts in fluid mechanics (flow and pressure).
— Unit manipulation and order-of-magnitude estimation.