ESIROI
ÉCOLE D'INGÉNIEURS
UNIVERSITÉ DE LA RÉUNION

DEPARTMENT : *AA*
SEMESTER : *S8*

IDENTIFICATION

Course code :	ESI-SPI-CI-AG4-S8-UE1-EC4
ECTS :	2

DURATION

Lectures :	4
Tutorial classes :	14
Labs :	8
Total :	26

Project :
Personnal work :

ASSESSMENT

TEACHING MATERIALS

LANGUAGE

English

CONTACT

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UE : UE8-PROD

COURSE : Reactors and Bioreactors

SCOPE OF THE COURSE

OBJECTIVES

This course aims to train students in the design, sizing, modeling, and operation of chemical and biological reactors, with a particular focus on agri-industrial processes. It ensures an integrated understanding of phenomena at different scales, from the microscopic scale (chemical kinetics, enzymatic kinetics, microbial growth) to their implementation at the industrial scale (reactors, bioreactors, fermentation processes). The course integrates biological constraints (microorganisms, enzymes, cellular needs), physicochemical constraints (mass and heat transfers, hydrodynamics), and industrial constraints (productivity, energy consumption, scale-up). Special attention is given to industrial fermentations (alcoholic, lactic, acetic, citric, etc.) and the operating conditions influencing their performance (temperature, pH, aeration, agitation).

COMPETENCE AND SKILLS

Upon completion of this course, the student will be able to establish material and energy balances for chemical and biological reaction systems, analyze the kinetics of processes including microbial growth (growth phases, Monod law), enzymatic kinetics (Michaelis-Menten model), and chemical reaction kinetics, and model substrate consumption as well as product and biomass formation. The student will also know how to identify and select an appropriate type of reactor (batch, fed-batch, continuous, CSTR, Plug flow), size a reactor (volume, residence time, conversion), and analyze bioreactor performance in terms of yield (biomass, substrate, energy), productivity, and oxygen transfer (kLa). The student will be able to study transfer phenomena (gas-liquid, liquid-solid mass transfer, heat transfer), understand reactor hydrodynamics (agitation, mixing, residence time), simulate and optimize a process, and scale up a process from laboratory to industrial scale.

PROGRAM

The program covers the essential foundations of process engineering by integrating chemical kinetics, applied thermodynamics, and basic microbiology, while considering cellular needs in nutrients, oxygen, and energy. It then addresses fermentations and bioprocesses through the definition of industrial fermentations (alcoholic, lactic, acetic, citric), the different types of processes, and the culture of microorganisms in fermenters (bioreactors), including the use of biosensors for monitoring and controlling biological systems. The course also develops the kinetics of biological processes, including microbial growth (growth phases), the Monod model, and enzymatic kinetics with fundamental concepts and the Michaelis-Menten model. The different types of reactors and bioreactors (batch, fed-batch, continuous, CSTR, Plug flow) are studied in relation to operating parameters such as temperature, pH, aeration, and agitation. The program also includes the study of transfer phenomena and hydrodynamics (oxygen transfer kLa, mixing, agitation, residence time), as well as material and energy balances and biomass yields. It further addresses process modeling and simulation through balance equations, followed by design principles (reactor sizing, energy consumption, heat and mass transfers, multi-scale study from microscopic to macroscopic). Finally, it covers scale-up for industrial applications in the agri-food sector.

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BIBLIOGRAPHY

Doran, P.M. (2012). Bioprocess Engineering Principles. Academic Press. Froment, G.F., Bischoff, K.B. & De Wilde, J. (2010). Chemical Reactor Analysis and Design. Wiley. Levenspiel, O. (1999). Chemical Reaction Engineering (3rd ed.). John Wiley & Sons. Nauman, E.B. (2008). Chemical Reactor Design, Optimization, and Scaleup. Wiley-AIChE. Villadsen, J., Nielsen, J. & Lidén, G. (2011). Bioreaction Engineering Principles. Springer. Villermaux, J. (1993). Chemical Reaction Engineering. Technique et Documentation

REQUIREMENTS

— Complementary Physics (Thermodynamics and Fluid Mechanics).
— Transfer Phenomena : Basic concepts of mass and heat transfer.
— Biochemistry, General Microbiology and Food Microbiology (Metabolism, Bacterial Growth, Enzyme Structures).
— Mathematics : Simple differential equations and integral calculus