Course guide
390333 - TMSB - Mass Transfer in Biological Systems

Last modified: 27/06/2024

Unit in charge: Barcelona School of Agri-Food and Biosystems Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: BACHELOR'S DEGREE IN BIOSYSTEMS ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: Pineda Soler, Eloy

Others: Prats Soler, Clara

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Heat and mass transfer in biological systems.
2. Ability to use and manage the technology and operational methods of bioreactors.
3. Design of processes and facilities for production of biological materials.

Transversal:
4. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

Lectures will consist in the introduction of concepts necessary to achieve the objectives of the course, examples of application of these concepts to problem solving will be also presented. Practical lessons will consist of problem sessions, in these sessions students will work in teams with the supervision of the teacher during the activity. Capacity for teamwork and problem solving of students is enhanced. The supporting material includes course manual programs, collections of problems and notes.
This material will be available via the ATENEA platform.

LEARNING OBJECTIVES OF THE SUBJECT

The students will acquire scientific and technical foundations needed to calculate and design processes involving mass transfer due to diffusion both under steady state and transient regimes (molecular diffusion in gases, liquids, biological solutions and ice as well as in solids), due to convection (convection coefficients of mass transfer) and by means of separation processes (evaporation, drying, gas-liquid, liquid vapor, liquid-liquid, solid-fluid, membranes) causing physical and chemical changes in biological materials. The student will become familiar with the properties of gases, liquids, solids, solutions and suspensions and phase changes related to mass transfer processes. From a proper understanding of the scientific basis of diffusion and convective transfer as well as details of individual separation processes, the student must be able to design complex processes for transforming biological materials.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	40,0	26.67
Hours small group	20,0	13.33

Total learning time: 150 h

CONTENTS

MASS TRANSFER PRINCIPLES: MOLECULAR DIFFUSION

Description:
Introduction. Analogy between heat and mass transfer.
Properties of gases, liquids, biological solutions, ice and solids.
Molecular diffusion types: concentration gradient, pressure, heat, forced.
Fick's law. Flow. Continuity equation.
Stationary diffusion in binary systems.
Diffusion through walls.
Non-stationary. diffusion cases: mobile medium, gas mixture, counterdiffusion.
Mass transfer in multicomponent systems.

Related activities:
Activitat 1 Lectures
Activitat 2 Individual evaluation tests
Activitat 3 Practical lessons
Activitat 4 Exercices

Full-or-part-time: 24h
Theory classes: 6h
Laboratory classes: 3h
Self study : 15h

CONVECTIVE MASS TRANSFER

Description:
Introduction to convective mass transfer. Analogy with convective heat transfer.
Convective mass transfer coefficient. Sherwood number.
Dimensional Analysis. Schmidt number (kinematic viscosity / mass diffusivity) and Lewis (thermal diffusivity / mass diffusivity).
Particular cases. Relations.
Simultaneous heat and mass transfer.
Numerical methods.

Related activities:
Activitat 1 Lectures
Activitat 2 Individual evaluation tests
Activitat 3 Practical lessons
Activitat 4 Exercices
Activitat 5 Practical calculation lessons in the computers room

Full-or-part-time: 19h
Theory classes: 6h
Laboratory classes: 2h
Self study : 11h

PSICHROMETRY. WETTING AND DRYING PROCESSES

Description:
Psychrometry.
Properties of moist air.
Psychrometric chart.
Adiabatic saturation temperature and wet-bulb temperature. Lewis ratio.
Mass and energy balances.
Humidification.
Dehumidification. Air and solids.
Cooling. Evaporative cooling. Cooling towers.

Related activities:
Activitat 1 Lectures
Activitat 2 Individual evaluation tests
Activitat 3 Practical problem-solving lessons
Activitat 4 Exercices

Full-or-part-time: 21h
Theory classes: 6h
Laboratory classes: 4h
Self study : 11h

SEPARATION PROCESSES: GAS-LIQUID, VAPOR-LIQUID

Description:
Phase equilibrium. Solubility of gases in liquids.
Absorption of gases in liquids.
Operations in stages.
Vapor-liquid equilibrium stages. Boiling point.
Distillation. McCabe-Thiele.

Related activities:
Activity 1 Lectures
Activity 2 Individual evaluation tests
Activity 3 Practical problem-solving lessons
Activity 4 Exercices

Full-or-part-time: 18h
Theory classes: 6h
Laboratory classes: 2h
Self study : 10h

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SEPARATAION PROCESSES: LIQUID-LIQUID AND FLUID-SOLID

Description:
Introduction to adsorption processes.
Ion exchange processes.
Liquid-liquid extraction. Single-stage processes and multiple stage.
Liquid-solid leaching. Single-stage processes and multiple stage.
Crystallization.

Related activities:
Activity 1 Lectures
Activity 2 Individual evaluation tests
Activity 3 Practical problem-solving lessons
Activity 4 Exercices

Full-or-part-time: 29h
Theory classes: 6h
Laboratory classes: 4h
Self study : 19h

SEPARATION USING MEMBRANES

Description:
Introduction. Membrane types.
Liquid permeable membranes. Dialysis.
Gas permeable membranes. Gas separation. Equations.
Numerical methods.
Reverse osmosis processes. Applications.
Microfiltration and ultrafiltration.

Related activities:
Activity 1 Lectures
Activity 2 Individual evaluation tests
Activity 3 Practical problem-solving lessons
Activity 4 Exercices

Full-or-part-time: 22h
Theory classes: 6h
Laboratory classes: 3h
Self study : 13h

MECHANICAL SEPARATION

Description:
Introduction. Classifying mechanical separation methods.
Solid-liquid filtration.
Sedimentation: separation of particles from a fluid.
Separation and selection of particles by centrifugation.
Reduction of particle size.

Related activities:
Activity 1 Lectures
Activity 2 Individual evaluation tests
Activity 3 Practical problem-solving lessons
Activity 4 Exercices

Full-or-part-time: 17h
Theory classes: 4h
Laboratory classes: 2h
Self study : 11h

ACTIVITIES

ACTIVITY 1: LECTURES

Full-or-part-time: 40h
Theory classes: 40h

ACTIVITY 3: PRACTICAL LESSONS

Full-or-part-time: 50h
Self study: 30h
Laboratory classes: 20h

GRADING SYSTEM

N1 = Written test 1: 35%
N2 = Written test 2: 35%
N3 = Delivered exercises: 30%

Nfinal: 0,35N1 + 0,35N2 + 0,3N3

BIBLIOGRAPHY

Basic:
- Geankoplis, Christie J. Transport processes and unit operations. Englewood Cliffs: Prentice-Hall International, 1993. ISBN 013045253X.

Complementary:
- Griskey, Richard G. Transport phenomena and unit operations: a combined approach. New York: Wiley-Interscience, 2002. ISBN 0471438197.
- McCabe, Warren L. Unit operations of chemical engineering. Boston: McGraw-Hill, 2005. ISBN 0071247106.
- Perry, Robert H.; Green, Don W.; Maloney, James O. Manual del ingeniero químico [on line]. 4ª ed. Madrid: McGraw-Hill, 2001

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- Çengel, Yunus A. Transferencia de calor y masa : un enfoque práctico. 3a ed. México [etc.]: McGraw-Hill, 2007. ISBN 9789701061732.
- Doran, Pauline M. Principios de ingeniería de los bioprocesos. Zaragoza: Acribia, cop. 1998. ISBN 8420008532.