# Course guide
# 390333 - TMSB - Mass Transfer in Biological Systems

**Last modified:** 17/09/2024

**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

## 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 [on line]. New York: Wiley-Interscience, 2002 [Consultation: 22/01/2025]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/0471722057. 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 [Consultation: 16/07/2022]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=6572. ISBN 8448130081.
- 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.