

Transport Phenomena

Code: 102398
ECTS Credits: 6

Degree	Type	Year	Semester
2500897 Chemical Engineering	OT	4	1

Contact

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Teaching groups languages

You can check it through this [link](#). To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

David Gabriel Buguña

Prerequisites

Have completed and passed the subjects of the degree in the areas of mathematics, physics, chemistry, as well as macroscopic balances and computer applications.

Objectives and Contextualisation

Stablish the mathematical model that describes a system from the equations of change of momentum, mass and energy.

Solve the system model by analytical or numerical means, and analyze and discuss the solution.

Competences

- Apply relevant knowledge of the basic sciences, such as mathematics, chemistry, physics and biology, and the principles of economics, biochemistry, statistics and material science, to comprehend, describe and resolve typical chemical engineering problems.
- Communication
- Develop personal work habits.
- Develop thinking habits.
- Understand and apply the basic principles on which chemical engineering is founded, and more precisely: balances of matter, energy and thermodynamic momentum, phase equilibrium and kinetic

chemical equilibrium of the physical processes of matter, energy and momentum transfer, and kinetics of chemical reactions

Learning Outcomes

1. Apply relevant knowledge of mathematics, physics and chemistry to the preparation and resolution of transport models.
2. Apply the basic principles of chemical engineering to the preparation and resolution of transport models.
3. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
4. Develop critical thinking and reasoning
5. Manage available time and resources. Work in an organised manner.
6. Practice the fundamental laws of thermodynamics in chemical process engineering problems.
7. Prevent and solve problems.
8. Work autonomously.

Content

1.- Introduction to transport phenomena

History and context in Chemical Engineering, Transport Phenomena and Unit Operations. Systems analysis. Balances of matter, energy and amount of movement. EDP's, Computer Fluidodynamics: CFD. Transport mechanisms

2.- Mathematical expressions in the equations of change

Vectorial equations of balance sheets. Coordinate systems: Cartesian, cylindrical and spherical. Vector operations (algebraic and differential). Expansion of balance equations: Total mass; momentum, heat energy and balance by components. Boundary conditions for resolution.

3.- Mass balance: continuity equation

Deduction of the balance sheet equation.

4.- Balance of linear momentum

Balance and Newton's second law. Expansion of equations of momentum balances. Newton's law of viscosity: 3D transport equation. Other expressions of the balance: Navier-Stokes, Euler. Non-Newtonian fluids. Example of application: Fluid flow velocity profile in a tube: Eq. Hagen-Poiseuille. Incompressible fluids and pressure: Other variables: Vorticity, current lines, pressure equation.

5.- Energy balance

Expressions of the equations of total, mechanical and calorific energy. Fourier's law of heat conduction. 3D transport. Expansion of heat equation equations. Example of application in analytical resolution: ENE 1D conduction (semi-infinite, error-function and concrete geometries: Gurney-Lurie. Example of application in numerical resolution ENE 2D / 3D conduction: Integration software.

6.- Mass balance for components.

Balance in mass and molar units: Expansion of balance equations. Fick's law of diffusion: 3D transport equation. Examples of analytical resolution in systems in EE without chemical reaction: Diffusion of one component through stationary film and equimolecular counterdiffusion. Examples of analytical resolution in systems in ENE without chemical reaction: semi-infinite error-function and concrete geometries-Gurney-Lurie. Examples of analytical resolution in systems with generation (chemical reaction): homogeneous RQ, heterogeneous catalysis

7.- Transport of property to the interfaces: transport coefficients

General definitions of transport coefficients. Calculation by analogies between FT. Boundary layer theory: solving equations on the boundary layer. Film theory.

8.- Turbulence

Concept of turbulence, turbulence scales. Characteristics of turbulent flow: Fluctuations. Mathematical Solving of Turbulence: Navier Stokes Equation. Numerical methods: Discretization of EDPs. RANS resolution (Reynolds Average Navier Stokes): turbulent flow densities and turbulent properties. Application example: Numerical resolution of the velocity profile in a pipe.

Methodology

The subject is developed through theory classes, problems and seminars.

Theory classes: Classroom classes

Problems classes: Resolution of problems corresponding to the subject. Discussion with the students about the solution strategies and their execution.

Seminars: Seminars on the use of software for the resolution of problems with differential equations with partial derivatives (EDP)

During the course, homework is proposed that use analytical or numerical methods to solve the problem.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	30	1.2	1, 2, 4
Problems solving	15	0.6	1, 2, 4, 6, 8
seminars	5	0.2	2, 3, 4, 5, 6, 7
Type: Supervised			
Homework	40	1.6	1, 2, 3, 4, 5, 6, 8
exam	4	0.16	1, 2, 3, 5, 6
Type: Autonomous			
Study, problems solving	56	2.24	1, 2, 4, 5, 6, 7, 8

Assessment

Distribution of the grade: 30% works and 70% exams (partial written tests).

Continuous evaluation: minimum score of each part to pass the continuous assessment 3/10

1st partial test (PP1): 25% note.
2nd partial test (PP2): 45% note.
Work delivered (TR): 30% note.

Single assessment: those who accept the single assessment process by declaring it at the beginning of the course, will take the day of the second partial test, an additional part corresponding to the first part of the course.

Retaking Final test : There will be a final test for those students who have not passed the continuous assessment.

See more details the Catalan version of the guide

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Writing exams	70	0	0	1, 2, 3, 4, 5, 6, 7
homework	30	0	0	2, 3, 4, 5, 6, 7, 8

Bibliography

Christie J. Geankoplis, "Transport Processes and Separation Process Principles", 5th ed. Prentice-Hall, 2018

R.B. Bird, W.E. Steward, E.N. Lighfoot, "Transport Phenomena", revised 2nd ed. Wiley, 2007

Joel Plawsky, "Transport Phenomena Fundamentals", 3rd ed., CRC Press, 2014

Ismail Tosun, "Modeling in Transport Phenomena. A conceptual Approach", 2nd ed., Elsevier, 2007

Software

Free access partial differential equation integration software is used.