Transport Phenomena in Food Processes

Degree: Food Engineering	**Docente**: Prof. Gaetano Lamberti Prof. Francesco Marra	**Integrato**: NO	**Propedeuticità:** Nessuna	**Crediti**: 9
Anno: I	**Semestre**: II	**Codice**: 0622800020	**SSD**: ING-IND/24	**Tipologia**: Caratterizzante

Learning outcomes: expected learning outcomes and competences

The course aims to provide advanced knowledge of transport phenomena (momentum, energy, mass), with reference to food processes, and foodstuff properties.

Knowledge and understanding

The students will acquire knowledge on transport phenomena fundamentals, constitutive equations, equations of change (momentum, energy, mass).

Applying knowledge and understanding

The students will be able to properly apply and simplify the equations of change, and to select the proper solution approach.

Making judgements

The students will be trained to identify the most relevant phenomena, to evaluate the equation's terms order-of-magnitude and to recognize the applicability of simplifications.

Communication skills

To Know how to orally discuss a topic in the field of food engineering, from a modeling point of view.

Learning skills

To know how to apply the acquired knowledge in contexts even different than the ones presented during the course; to be able to deepen the topics dealt with within the course.

Prerequisites

Knowledge of basic thermodynamics and mathematics is required. The basics of transport phenomena, even if useful, will be summarized during the course.

Teaching methods

The course includes lectures, classroom/laboratory exercises.

Evaluation criteria

The evaluation will be carried out by a written test and an oral interview. The written test could be replaced (by students' choice) by homework tests and/or a project. The essential condition to pass the exam is the ability to identify, in a given problem, the most relevant phenomena and to write the proper model equations. The final mark, between eighteen and thirty cum laude, depends on the demonstrated ability to master the course's issues.

Attendance mode

Attendance to the course is strongly suggested.

Teaching language

English.

Place and time of delivery

The course is delivered at the Faculty of Engineering. Please look up into the Course webpage (www.minerva.unisa.it/serv/tpfp) for the indication of the timetable and of the classroom.

Course contents

Topics	Specific contents	Less. hours	Ex. hours	Lab. hours
Introduction to Transport Phenomena (TPs)	Definition and meanings of TPs - General framework of TPs - General rate equation - Simple experiments and definitions of transport properties - Molecular Fluxes - Convective Fluxes - Combined Fluxes - Transport properties: methods of measurements - modeling and predictions	5	2.5	
Balance Equations (BEs) or Field Equations (FEs)	Generalized balance equation (BE) - Balances: microscopic (differential) and macroscopic (integral) - Euler and Lagrange forms of BEs - Continuity, Momentum, Mechanical Energy, Thermal Energy, Single Specie BEs - Solving problem approach - Summary of BEs	5	2.5	
Dimensional Analysis (DA) and similarities	Introduction to DA - Buckingham π Theorem, Buckingham and Raleigh's methods - Similarities - Dimensional analysis of BE - Dimensionless numbers: list, meanings, applications - Scale-up basics	5	2.5	
Transport with more than one independent variables	Transient transport phenomena - Small time approximations (the penetration theory) - Stream functions - Potential functions	10	5	
Turbulence	Turbulent flow – time-smoothed BEs – turbulent fluxes and diffusivities – empirical expressions for turbulent fluxes: Eddy viscosity and Mixing Length – profiles near a wall – turbulence in ducts and jets – the κ-ε models	5	2.5	
Boundary layer (BL) theory	Laminar boundary layer – turbulent boundary layer – flow over submerged objects – entrance region for pipes – momentum, heat and mass transport in BL – interphase transport coefficients	5	2.5	
Rheology and rheometry	Introduction to rheology - viscosity: definition, dependencies, Newtonian and non-Newtonian fluids, viscosity measurements - viscoelasticity: definition, mechanical models, constitutive equations, dynamic testing	10	2.5	
Applications	Flows in conducts - Transport phenomena with phase change - Transport phenomena with chemical reactions – Measurements of engineering properties of foodstuff	15	5	5
Total hours		60	25	5

Course text-book

[1] R. B. Bird, W. E. Stewart, E. N. Lightfoot, "Transport phenomena", 2nd edition, John Wiley & Sons, New York, 2002.

Further suggested sources

[2] R. S. Brodkey, H. C. Hershey, "Transport Phenomena: A Unified Approach", Brodkey Publishing, Columbus, Ohio, 2001 (formerly: John Wiley & Sons, New York, 1988).
[3] I. Tosun, "Modeling in transport phenomena: A conceptual approach", 2nd edition, Elsevier Science, Amsterdam, 2007.
[4] M. Zlokarnik, "Scale-up in Chemical Engineering", WILEY-VCH Verlag GmbH & Co., Weinheim, 2002.
[5] A. Ibarz, G. V. Barbosa-Cánovas, "Unit operations in food engineering", CRC, Boca Raton, 2003.
[6] Course webpage: www.minerva.unisa.it/serv/tpfp