



Course guide

295504 - FETRA - Transport Phenomena

Last modified: 08/08/2024

Unit in charge: Barcelona East School of Engineering
Teaching unit: 713 - EQ - Department of Chemical Engineering.

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Optional subject).

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

LECTURER

Coordinating lecturer: EULALIA PLANAS CUCHI

Others: Primer quadrimestre:
ALBA ÀGUEDA COSTAFREDA - Grup: M1
EULALIA PLANAS CUCHI - Grup: M1

PRIOR SKILLS

Fundamentals of Chemistry, thermodynamics, differential equations, numerical computation

REQUIREMENTS

TERMODINÀMICA - Precorequisit

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

TEACHING METHODOLOGY

Lectures of theory and problems, participatory problem seminars, work on a case study



LEARNING OBJECTIVES OF THE SUBJECT

The course aims to introduce students in the joint study of the transfer of energy, matter and momentum. Give them to know the basic laws of these three phenomena, closely related, so they can formulate mathematical models that represent the fundamentals of the real problems of chemical processes. At the end of the course the student should be able to:

- OE1. Apply the laws governing the transfer of momentum, energy and matter and interrelate the three phenomena.
- OE2. Formulate mathematical models that represent complex real systems both steady state and unsteady.
- OE3. Propose models for the individual and global transport coefficients necessary for solving real problems.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	40.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

INTRODUCTION TO TRANSPORT PHENOMENA

Description:

What is chemical engineering?. Historical evolution of the chemical engineering discipline. Onset of transport phenomena as a discipline within chemical engineering. Fundamentals of property balances, integral and differential forms.

Specific objectives:

OE1

Related activities:

Theory lessons. Problem solving lessons. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

Full-or-part-time: 5h

Theory classes: 2h

Self study : 3h



VELOCITY EQUATIONS FOR MOLECULAR TRANSPORT

Description:

Introduction: behavior and physical states of matter. Transport of momentum: Newton's Law, viscosity, non-Newtonian fluids. Transport of heat energy: Fourier's Law, thermal conductivity. Transport of mass: Fick's law, diffusivity. General velocity equation.

Specific objectives:

OE1

Related activities:

Theory lessons. Problem solving lessons. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 20h

Theory classes: 6h

Laboratory classes: 2h

Self study : 12h

THE BALANCE EQUATIONS

Description:

The mass balance: the continuity equation, the combination of balance and rate equation. The momentum balance: equation of motion. The energy balance: energy equation. No dimensional conservation equations

Specific objectives:

OE1

Related activities:

Theory lessons. Problem solving lessons. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 19h 10m

Theory classes: 4h

Laboratory classes: 9h 45m

Self study : 5h 25m



STEADY STATE MOLECULAR TRANSPORT

Description:

Momentum transfer: speed profiles. Heat transport: temperature profiles. Mass transport: concentration profiles. Simultaneous transport of properties. Using non-dimensional conservation equations. Study of diffusion with chemical reaction

Specific objectives:

OE1, OE2

Related activities:

Theory lessons. Lessons of resolution of exercises. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 27h 45m

Theory classes: 7h 30m

Laboratory classes: 3h

Self study : 17h 15m

UNSTEADY-STATE MOLECULAR TRANSPORT

Description:

Balance equations. Solving the balance equations: application to finite and semi-infinite media

Specific objectives:

OE1, OE2

Related activities:

Inverse learning of theory lessons. Lessons of resolution of exercises. Independent learning. Assessment activities A1, A2

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 18h 45m

Theory classes: 4h 30m

Laboratory classes: 2h

Self study : 12h 15m



FLOW TURBULENCE

Description:

Description and approaches to the study of turbulence. Mean values technique. Equations of transport under turbulent conditions. Universal velocity distribution

Specific objectives:

OE1, OE2

Related activities:

Theory lessons. Lessons of resolution of exercises. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 11h 28m

Theory classes: 4h 30m

Laboratory classes: 1h

Self study : 5h 58m

BOUNDARY LAYER THEORY

Description:

Introduction. The Prandtl theory: fundamental equations. Boundary layer on flat surfaces: laminar and turbulent regimes.

Specific objectives:

OE1,OE2

Related activities:

Theory lessons. Lessons of resolution of exercises. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 6h 15m

Theory classes: 1h 30m

Laboratory classes: 1h

Self study : 3h 45m



INDIVIDUAL AND GLOBAL TRANSPORT COEFFICIENTS

Description:

Individual transport coefficients. Momentum: the friction factor. Individual coefficients of heat and mass transfer. Theories about the transport coefficients: film, penetration, etc.. Global transport coefficients. Transfer units.

Specific objectives:

OE1, OE2, OE3

Related activities:

Theory lessons. Lessons of resolution of exercises. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 18h

Theory classes: 4h

Laboratory classes: 2h

Self study : 12h

ANALOGY BETWEEN THE TRANSPORT PHENOMENA

Description:

Basic relationships. Description of different analogies: Reynolds and Sherwood-Karman, Prandtl-Taylor and Colburn, Karman and Sherwood.

Specific objectives:

OE1, OE2, OE3

Related activities:

Theory lessons. Problem solving lessons. Independent learning. Assessment activities A1

Related competencies :

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 6h

Theory classes: 1h 30m

Self study : 4h 30m



ACTIVITIES

A1-QUESTIONNAIRES

Description:

Test questionnaires. Continuous evaluation which will be carried out along the semester

Specific objectives:

OE1, OE2, OE3

Material:

Notes from class.Slides. Reading. Exercises solved in class

Delivery:

Answers to the questions of the questionnaire which will be handed in by the end of the activity

Related competencies :

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

Full-or-part-time: 4h 10m

Self study: 2h 10m

Theory classes: 2h

A2-RESOLUTION WITH MATLAB OF A NON-STEADY STATE CASE

Description:

Inverse learning through videos and validations by means of Atenea quiz. Resolution of a case in a non-steady state by the MATLAB program

Specific objectives:

OE1, OE2

Material:

Videos and quiz in Atenea. The description of the problem to be solved will be uploaded on Atenea. Notes of the class. Slides. MATLAB program

Delivery:

Solution of the quiz. Solution to the exercise, which will have to be introduced into Atenea

Related competencies :

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

Full-or-part-time: 7h

Self study: 5h

Laboratory classes: 2h



A3-PARTIAL EXAM

Description:

Exam consisting in the resolution of a problem

Specific objectives:

OE1, OE2

Material:

Notes from class. Slides. Exercises solved in class

Delivery:

Answer to the questions of the exam

Related competencies :

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

Full-or-part-time: 4h 10m

Self study: 2h 10m

Theory classes: 2h

A4-FINAL EXAM

Description:

Final exam of the course based on the resolution of exercises

Specific objectives:

OE1, OE2, OE3

Material:

Notes of the class. Slides. Solved exercises. Bibliographic material of support

Delivery:

Answers to the questions of the exam

Related competencies :

CEB-01. Solve mathematical problems that may arise in engineering. Apply knowledge of linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and partial differential equations; numerical methods; numerical algorithms; statistics and optimisation.

CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.

CEQUI-19. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Full-or-part-time: 9h

Self study: 6h

Theory classes: 3h

GRADING SYSTEM

FINAL RATE:

$$NF = 0.45 \cdot NEF + 0.25 \cdot NEP + 0.15 \cdot NAC + 0.15 \cdot NT$$

Where,

NEF: Rate of the final exam

NEP: Rate of the partial exam

NAC: Average rate of the continuous assessment questionnaires

NT: Rate of the task of solving a problem using Matlab

The course will have a reevaluation exam according to the calendar and rules of the EEBE, this exam will substitute the three scores NEP, NEP and NAC, so will count 90%. The students will be able to access the re-assessment test that meets the requirements set by the EEBE in its Assessment and Permanence Regulations (<https://eebe.upc.edu/ca/estudis/normatives-academiques/documents/eebe-normativa-avaluacio-i-permanencia-18-19-aprovat-je-2018-06-13.pdf>)

EXAMINATION RULES.

The partial and final exams can be made using all available bibliographic material: lecture notes, reference books, collection of problems, etc. continuous assessment tests (questionnaires) can only be done using class notes, readings and book problems.

BIBLIOGRAPHY

Basic:

- Bird, R. Byron; Stewart, Warren E; Lightfoot, Edwin N; Mato Vázquez, Fidel. Fenómenos de transporte : un estudio sistemático de los fundamentos de transporte de materia, energía y cantidad de movimiento. Barcelona: Reverté, 1982. ISBN 8429170502.
- Brodkey, Robert S; Hershey, Harry C. Transport phenomena : a unified approach. Columbus, Ohio: Brodkey Publishing, cop. 1988. ISBN 0972663584.
- Thomson, William J. Introduction to transport phenomena. Upper Saddle River: Prentice Hall, 2000. ISBN 0134548280.
- Beek, W. J; Muttzall, Klaus Max Karl; Heuven, J. W. van. Transport phenomena. 2nd ed. Chichester ; New York: Wiley, c1999. ISBN 0471999903.
- Deen, William M. Analysis of transport phenomena. New York [etc.]: Oxford University Press, 2013. ISBN 9780199740253.

Complementary:

- Poling, Bruce E.; Praunitz, John M.; O'Connell, John P. The Properties of gases and liquids. 5th ed. New York [etc.]: McGraw-Hill, cop. 2001. ISBN 0070116822.
- Schlichting, Hermann; Gersten, Klaus. Boundary-layer theory [on line]. 9th ed. 2017. Berlin [etc.]: Springer-Verlag, cop. 2017 [Consultation: 26/05/2020]. Available on: <http://dx.doi.org/10.1007/978-3-662-52919-5>. ISBN 9783662529195.

RESOURCES

Other resources:

Book of Problems and Tables