295504 - FETRA - Transport Phenomena

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 713 - EQ - Department of Chemical Engineering
Academic year: 2018

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

ECTS credits: 6

Teaching languages: Catalan

Teaching staff
Coordinator: Planas Cuchi, Eulalia
Others: Pastor Ferrer, Elsa
Águeda Costafreda, Alba

Opening hours
Timetable: Ask for your attention time directly to the Professor by email

Prior skills
Fundamentals of Chemistry, thermodynamics, differential equations, numerical computation

Requirements
To have attended the courses that provide the required skills

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.
CEBI-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.
295504 - FETRA - Transport Phenomena

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

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>60h</th>
<th>40.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
## 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.

**Related activities:**

**Specific objectives:**
OE1

**Learning time:** 5h
- Theory classes: 2h
- Self study: 3h

## VELOCITY EQUATIONS FOR MOLECULAR TRANSPORT

**Description:**

**Related activities:**

**Specific objectives:**
OE1

**Learning 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

**Related activities:**

**Specific objectives:**
OE1

**Learning time:** 19h 10m
- Theory classes: 4h
- Laboratory classes: 9h 45m
- Self study: 5h 25m
<table>
<thead>
<tr>
<th>Topic</th>
<th>Learning time:</th>
<th>Theory classes:</th>
<th>Laboratory classes:</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEADY STATE MOLECULAR TRANSPORT</td>
<td>27h 45m</td>
<td>7h 30m</td>
<td>3h</td>
<td>17h 15m</td>
</tr>
<tr>
<td>Description:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Momentum transfer: speed profiles.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat transport: temperature profiles.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass transport: concentration profiles.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous transport of properties.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using non-dimensional conservation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>equations. Study of diffusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with chemical reaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related activities:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theory lessons. Lessons of resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of exercises. Independent learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment activities A1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific objectives:</td>
<td>OE1, OE2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| UNSTEADY-STATE MOLECULAR TRANSPORT      | 18h 45m        | 4h 30m          | 2h                   | 12h 15m    |
| Description:                            |                |                 |                      |            |
| Balance equations. Solving the balance  |                |                 |                      |            |
| equations: application to finite and    |                |                 |                      |            |
| semi-infinite media                     |                |                 |                      |            |
| Related activities:                     |                |                 |                      |            |
| Inverse learning of theory lessons      |                |                 |                      |            |
| Lessons of resolution of exercises.     |                |                 |                      |            |
| Independent learning. Assessment        |                |                 |                      |            |
| activities A1, A2                       |                |                 |                      |            |
| Specific objectives:                    | OE1, OE2       |                 |                      |            |

| FLOW TURBULENCE                         | 11h 28m        | 4h 30m          | 1h                   | 5h 58m     |
| Description:                            |                |                 |                      |            |
| Description and approaches to the study |                |                 |                      |            |
| of turbulence. Mean values technique.   |                |                 |                      |            |
| Equations of transport under            |                |                 |                      |            |
| turbulent conditions. Universal         |                |                 |                      |            |
| velocity distribution                    |                |                 |                      |            |
| Related activities:                     |                |                 |                      |            |
| Theory lessons. Lessons of resolution   |                |                 |                      |            |
| of exercises. Independent learning      |                |                 |                      |            |
| Assessment activities A1                | OE1, OE2       |                 |                      |            |
### Boundary Layer Theory

**Learning time:** 6h 15m  
Theory classes: 1h 30m  
Laboratory classes: 1h  
Self study: 3h 45m

**Description:**  

**Related activities:**  

**Specific objectives:**  
OE1, OE2

### Individual and Global Transport Coefficients

**Learning time:** 18h  
Theory classes: 4h  
Laboratory classes: 2h  
Self study: 12h

**Description:**  

**Related activities:**  

**Specific objectives:**  
OE1, OE2, OE3

### Analogy Between the Transport Phenomena

**Learning time:** 6h  
Theory classes: 1h 30m  
Laboratory classes: 0h  
Self study: 4h 30m

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

**Related activities:**  

**Specific objectives:**  
OE1, OE2, OE3
## Planning of activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours</th>
<th>Description</th>
<th>Support materials</th>
<th>Specific objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1-QUESTIONNAIRES</strong></td>
<td>4h 10m</td>
<td>Test questionnaires. Continuous evaluation which will be carried out along the semester</td>
<td>Notes from class. Slides. Reading. Exercises solved in class</td>
<td>OE1, OE2, OE3</td>
</tr>
<tr>
<td><strong>A2-RESOLUTION WITH MATLAB OF A NON-STEADY STATE CASE</strong></td>
<td>7h</td>
<td>Inverse learning through videos and validations by means of Atenea quiz. Resolution of a case in a non-steady state by the MATLAB program</td>
<td>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</td>
<td>OE1, OE2</td>
</tr>
<tr>
<td><strong>A3-PARTIAL EXAM</strong></td>
<td>4h 10m</td>
<td>Exam consisting in the resolution of a problem</td>
<td>Notes from class. Slides. Exercises solved in class</td>
<td>OE1, OE2</td>
</tr>
</tbody>
</table>
A4-FINAL EXAM

<table>
<thead>
<tr>
<th>Description:</th>
<th>Hours: 9h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final exam of the course based on the resolution of exercises</td>
<td>Theory classes: 3h</td>
</tr>
<tr>
<td></td>
<td>Self study: 6h</td>
</tr>
</tbody>
</table>

Support materials:
Notes of the class. Slides. Solved exercises. Bibliographic material of support

Descriptions of the assignments due and their relation to the assessment:
Answers to the questions of the exam

Specific objectives:
OE1, OE2, OE3

Qualification system

FINAL RATE:

\[
NF = 0.5 \cdot NEF + 0.25 \cdot NEP + 0.15 \cdot NEP + 0.15 \cdot NAC + 0.1 \cdot NT
\]

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)

Regulations for carrying out activities

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:


Complementary:


Others resources:

Book of Problems and Tables