295504 - FETRA - Transport Phenomena

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 713 - EQ - Department of Chemical Engineering
Academic year: 2019
Degree: BACHELOR'S DEGREE IN CHEMICAL 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 ELECTRICAL ENGINEERING (Syllabus 2009). (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 BIOMEDICAL 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)
BACHELOR'S DEGREE IN BIOMEDICAL 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 ENERGY ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan

Teaching staff
Coordinator: EULALIA PLANAS CUCHI
Others: Primer quadrimestre:
ALBA ÁGUEDA COSTAFREDA - M10
EULALIA PLANAS CUCHI - M10

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
TERMODINÀMICA - Prerequisite

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
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.

Learning objectives of the subject

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>60h</th>
<th>40.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time: 150h</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>

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

| **INTRODUCTION TO TRANSPORT PHENOMENA** | **Learning time:** 5h  
Theory classes: 2h  
Self study : 3h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Related activities:</strong></td>
<td>Theory lessons. Problem solving lessons. Independent learning. Assessment activities A1</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>OE1</td>
</tr>
</tbody>
</table>

| **VELOCITY EQUATIONS FOR MOLECULAR TRANSPORT** | **Learning time:** 20h  
Theory classes: 6h  
Laboratory classes: 2h  
Self study : 12h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Related activities:</strong></td>
<td>Theory lessons. Problem solving lessons. Independent learning. Assessment activities A1</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>OE1</td>
</tr>
</tbody>
</table>

| **THE BALANCE EQUATIONS** | **Learning time:** 19h 10m  
Theory classes: 4h  
Laboratory classes: 9h 45m  
Self study : 5h 25m |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>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</td>
</tr>
<tr>
<td><strong>Related activities:</strong></td>
<td>Theory lessons. Problem solving lessons. Independent learning. Assessment activities A1</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>OE1</td>
</tr>
<tr>
<td>Module</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
### BOUNDARY LAYER THEORY

**Description:**

**Related activities:**

**Specific objectives:**
OE1, OE2

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>6h 15m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>1h 30m</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>1h</td>
</tr>
<tr>
<td>Self study :</td>
<td>3h 45m</td>
</tr>
</tbody>
</table>

### INDIVIDUAL AND GLOBAL TRANSPORT COEFFICIENTS

**Description:**

**Related activities:**

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

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>18h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>4h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Self study :</td>
<td>12h</td>
</tr>
</tbody>
</table>

### ANALOGY BETWEEN THE TRANSPORT PHENOMENA

**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

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>6h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>1h 30m</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study :</td>
<td>4h 30m</td>
</tr>
</tbody>
</table>
## Planning of activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours: 4h 10m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1-QUESTIONNAIRES</strong></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td><strong>A2-RESOLUTION WITH MATLAB OF A NON-STEADY STATE CASE</strong></td>
<td>Self study: 2h 10m</td>
</tr>
<tr>
<td><strong>A3-PARTIAL EXAM</strong></td>
<td>Hours: 7h</td>
</tr>
<tr>
<td><strong>A4-MAKING WITH MATLAB OF A NON-STEADY STATE CASE</strong></td>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td><strong>A5-PARTIAL EXAM</strong></td>
<td>Self study: 5h</td>
</tr>
</tbody>
</table>

### A1-QUESTIONNAIRES

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

**Support materials:**
Notes from class. Slides. Reading. Exercises solved in class

**Descriptions of the assignments due and their relation to the assessment:**
Answers to the questions of the questionnaire which will be handed in by the end of the activity

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

### 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

**Support materials:**
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

**Descriptions of the assignments due and their relation to the assessment:**
Solution of the quiz. Solution to the exercise, which will have to be introduced into Atenea

**Specific objectives:**
OE1, OE2

### A3-PARTIAL EXAM

**Description:**
Exam consisting in the resolution of a problem

**Support materials:**
Notes from class. Slides. Exercises solved in class

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

**Specific objectives:**
OE1, OE2
295504 - FETRA - Transport Phenomena

<table>
<thead>
<tr>
<th><strong>A4-FINAL EXAM</strong></th>
<th><strong>Hours:</strong> 9h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></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