

**Proyecto/Guía docente de la asignatura***Project/Course Syllabus*

|                                                                                                 |                                                                                                          |                                     |                             |
|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------|-----------------------------|
| <b>Asignatura</b><br><i>Course</i>                                                              | Transport Phenomena Analysis /<br>Análisis de Fenómenos de Transporte                                    |                                     |                             |
| <b>Materia</b><br><i>Subject area</i>                                                           | Thermodynamics and Transport in Chemical Processes / Termodinámica y Transporte en los Procesos Químicos |                                     |                             |
| <b>Módulo</b><br><i>Module</i>                                                                  | Process & Product Engineering / Ingeniería de Procesos y Producto                                        |                                     |                             |
| <b>Titulación</b><br><i>Degree Programme</i>                                                    | Master in Chemical Engineering/ Máster en Ingeniería Química                                             |                                     |                             |
| <b>Plan</b><br><i>Curriculum</i>                                                                | 542                                                                                                      | <b>Código</b><br><i>Code</i>        | 53741                       |
| <b>Periodo de impartición</b><br><i>Teaching Period</i>                                         | 2nd Semester /<br>2º CUATRIMESTRE                                                                        | <b>Tipo/Carácter</b><br><i>Type</i> | COMPULSORY /<br>OBLIGATORIA |
| <b>Nivel/Ciclo</b><br><i>Level/Cycle</i>                                                        | Master                                                                                                   | <b>Curso</b><br><i>Course</i>       | 1º                          |
| <b>Créditos ECTS</b><br><i>ECTS credits</i>                                                     | 4.5 ECTS                                                                                                 |                                     |                             |
| <b>Lengua en que se imparte</b><br><i>Language of instruction</i>                               | English                                                                                                  |                                     |                             |
| <b>Profesor/es responsable/s</b><br><i>Responsible Teacher/s</i>                                | ÁNGEL MARTÍN MARTÍNEZ<br>SERGIO BORDEL VELASCO                                                           |                                     |                             |
| <b>Datos de contacto (E-mail, teléfono...)</b><br><i>Contact details (e-mail, telephone...)</i> | angel.martin.martinez@uva.es<br>sergio.bordel@uva.es                                                     |                                     |                             |
| <b>Departamento</b><br><i>Department</i>                                                        | Ingeniería Química y Tecnología del Medio Ambiente                                                       |                                     |                             |
| <b>Fecha de revisión por el Comité de Título</b><br><i>Review date by the Degree Committee</i>  | 13/07/2026                                                                                               |                                     |                             |

En caso de guías bilingües con discrepancias, la validez será para la versión en español.

*In the case of bilingual guides with discrepancies, the Spanish version will prevail.*

**1. Situación / Sentido de la Asignatura*****Course Context and Relevance*****1.1 Contextualización*****Course Context***

This subject is taught in the second semester of the first year of the Master's Degree in Chemical Engineering. The fundamentals of the transport processes described from a rigorous mathematical perspective is taught following a practical approach in which students develop the ability to make use of conservation equations, proceeding to their integration and calculating the derived magnitudes necessary in the design and analysis of real processes.

**1.2 Relación con otras materias*****Connection with other subjects***

This subject belongs to the module "Process and Product Engineering", and is considered closely related to other subjects of the module in the same semester, especially with 53747 DISEÑO DE PROCESOS CON REACCIÓN and 53748 DISEÑO DE PROCESOS DE TRANSFERENCIA DE MATERIA.

**1.3 Prerrequisitos*****Prerequisites***

Basic knowledge of transport processes (heat, matter, momentum). Ability to apply mathematical tools for analytical and numerical resolution of differential equations. Use of scientific calculation programs (Matlab/Python)



## 2. Resultados del proceso de formación y de aprendizaje (RD 822/2021) o competencias (RD 1393/2007)

*Learning outcomes (RD 822/2021) or competences (RD 1393/2007)*

### 2.1 (RD1393/2007) Competencias Generales

#### *General Competences*

- CG01. Capacidad para aplicar el método científico y los principios de la ingeniería y economía, para formular y resolver problemas complejos en procesos, equipos, instalaciones y servicios, en los que la materia experimente cambios en su composición, estado o contenido energético, característicos de la industria química y de otros sectores relacionados entre los que se encuentran el farmacéutico, biotecnológico, materiales, energético, alimentario o medioambiental.
- CG05. Saber establecer modelos matemáticos y desarrollarlos mediante la informática apropiada, como base científica y tecnológica para el diseño de nuevos productos, procesos, sistemas y servicios, y para la optimización de otros ya desarrollados.
- CG11. Poseer las habilidades del aprendizaje autónomo para mantener y mejorar las competencias propias de la ingeniería química que permitan el desarrollo continuo de la profesión

### 2.2 (RD1393/2007) Competencias Específicas

#### *Specific Competences*

- CEP01. Aplicar conocimientos de matemáticas, física, química, biología y otras ciencias naturales, obtenidos mediante estudio, experiencia, y práctica, con razonamiento crítico para establecer soluciones viables económicamente a problemas técnicos.
- CEP03. Conceptualizar modelos de ingeniería, aplicar métodos innovadores en la resolución de problemas y aplicaciones informáticas adecuadas, para el diseño, simulación, optimización y control de procesos y sistemas.



### 3. Objetivos

#### **Course Objectives**

- To propose and solve, in particular cases, the general equation of conservation of any extensive property.
- Calculate property flows.
- Estimate the value of transport properties.
- To know the usefulness of the main theories on the boundary layer.
- Apply theoretical knowledge to propose and solve models of transport phenomena numerically or analytically.



**4. Contenidos y/o bloques temáticos****Course Contents and/or Modules****Bloque 1: Transport properties**

Carga de trabajo en créditos ECTS: 1,0  
 Workload in ECTS credits:

**a. Contextualización y justificación****a. Context and rationale**

In this section, the experimental measurement and the theoretical estimation of the transport properties (viscosity, conductivity and diffusivity) are studied

**b. Objetivos de aprendizaje****b. Learning objectives**

- To know the main experimental methods of determining transport properties.
- To apply the kinetic theory of gases to describe transport processes and evaluate transport properties.
- To apply semi-empirical methods to estimate transport properties

**c. Contenidos****c. Contents**

1. Introduction to transport properties: constitutive equations of Newton, Fourier and Fick.
2. Transport properties of non-Newtonian fluids
3. Experimental measurement of transport properties
4. Estimation of transport properties: Kinetic theory. Semi-empirical methods.

**d. Métodos docentes****d. Teaching and Learning methods**

Classes take place in the computer room in a practical way. The teacher guides the class through explanations followed by the development of practical cases. Necessary resources: Virtual classroom (Moodle) Virtual Campus Programming software Problem solving using programming in PYTHON, MATLAB and Excel-VBA.

**e. Plan de trabajo****e. Work plan**

Experimental methods are presented through a theoretical presentation followed by a visit to the laboratories. Kinetic theory and estimation methods are studied through the development of practical examples.

**f. Evaluación****f. Assessment**

See section 7

**g Material docente****g Teaching material**

### g.1 Bibliografía básica

#### *Required Reading*

F. W. Sears, G. L. Salinger. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, 3<sup>rd</sup> Ed. Addison Wesley, 1975.

B. E. Poling, J. M. Prausnitz, J. P. O'Connell, Properties of Gases and Liquids, 5th Ed. Mc Graw-Hill, 2000

### g.2 Bibliografía complementaria

#### *Supplementary Reading*

R. Soto. Kinetic Theory and Transport Phenomena. Oxford University Press, 2016.

### g.3 Otros recursos telemáticos (píldoras de conocimiento, blogs, videos, revistas digitales, cursos masivos (MOOC), ...)

*Additional Online Resources (microlearning units, blogs, videos, digital journals, massive online courses (MOOC), etc.)*

### h. Recursos necesarios

#### *Required Resources*

Virtual Classroom (Moodle)

Virtual Campus Programming software

Problem solving using programming in PYTHON, MATLAB and Excel-VBA.

### i. Temporalización

#### *Course Schedule*

| CARGA ECTS<br>ECTS LOAD | PERIODO PREVISTO DE DESARROLLO<br>PLANNED TEACHING PERIOD |
|-------------------------|-----------------------------------------------------------|
| 1,0 ECTS                | Weeks 1-3                                                 |

## Bloque 2: Transport processes

Carga de trabajo en créditos ECTS: 3,5  
*Workload in ECTS credits:*

### a. Contextualización y justificación

#### *a. Context and rationale*

In this section the formulation, analysis and resolution of transport problems based on their conservation equations is studied.

### b. Objetivos de aprendizaje

#### *b. Learning objectives*

- To propose and resolve, in particular cases, the general equation of conservation of any extensive property.
- Calculate property flows for molecular and turbulent transport.
- To know the usefulness of the main theories on the boundary layer and calculate transport coefficients



- Calculate transport coefficients using the analogies between transport phenomena.

### c. Contenidos

### c. Contents

5. Generalization of transport laws. Conservation equations.
6. Microscopic conservation equations. Application to systems with molecular and turbulent transport.
7. Boundary layer theories. Transport coefficients.
8. Numerical & Analytical solution of conservation equations

### d. Métodos docentes

### d. Teaching and Learning methods

Classes take place in the computer room in a practical way. The teacher guides the class through explanations followed by the development of practical cases. Necessary resources: Virtual classroom (Moodle) Virtual Campus Programming software Problem solving using programming in PYTHON, MATLAB and Excel-VBA.

### e. Plan de trabajo

### e. Work plan

Experimental methods are presented through a theoretical presentation followed by a visit to the laboratories. Kinetic theory and estimation methods are studied through the development of practical examples.

### f. Evaluación

### f. Assessment

See section 7

### g Material docente

### g Teaching material

#### g.1 Bibliografía básica

#### Required Reading

R. B. Bird, W. E. Stewart, E. N. Lightfoot. Transport Phenomena, 2nd ed. Wiley, 2001

#### g.2 Bibliografía complementaria

#### Supplementary Reading

R. S. Brodkey, H. C. Hersey. Transport phenomena: a unified approach. McGraw-Hill, 1988

I. Tosun. Modelling in Transport Phenomena. Elsevier Science, 2001

#### g.3 Otros recursos telemáticos (píldoras de conocimiento, blogs, videos, revistas digitales, cursos masivos (MOOC), ...)

**Additional Online Resources (microlearning units, blogs, videos, digital journals, massive online courses (MOOC), etc.)**

The virtual campus provides descriptive material and code of the examples studied.



## h. Recursos necesarios

### Required Resources

Virtual Classroom (Moodle)

Virtual Campus Programming software

Problem solving using programming in PYTHON, MATLAB and Excel-VBA.

## i. Temporalización

### Course Schedule

| CARGA ECTS<br>ECTS LOAD | PERIODO PREVISTO DE DESARROLLO<br>PLANNED TEACHING PERIOD |
|-------------------------|-----------------------------------------------------------|
| 3,5 ECTS                | Weeks 4-15                                                |

## 5. Métodos docentes y principios metodológicos

### Instructional Methods and guiding methodological principles

Classes are developed in the computer room in a practical way. The professor guides the class by explanations followed by the development of practical cases. Examples are provided to students to build on the knowledge acquired in the classes, and begin to solve in the classroom.

## 6. Tabla de dedicación del estudiantado a la asignatura

### Student Workload Table

| ACTIVIDADES PRESENCIALES o PRESENCIALES o A DISTANCIA <sup>(1)</sup><br>FACE-TO-FACE/ON-SITE or ONLINE<br>ACTIVITIES <sup>(1)</sup> | HORAS<br>HOURS | ACTIVIDADES NO PRESENCIALES<br>INDEPENDENT / OFF-CAMPUS WORK | HORAS<br>HOURS |
|-------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------------------------------|----------------|
| Theory classes                                                                                                                      | 10             | Self-study                                                   | 67,5           |
| Practical classes                                                                                                                   | 30             |                                                              |                |
| Seminars + Lab visits                                                                                                               | 5              |                                                              |                |
|                                                                                                                                     |                |                                                              |                |
|                                                                                                                                     |                |                                                              |                |
|                                                                                                                                     |                |                                                              |                |
| Total presencial <i>Total face-to-face</i>                                                                                          | <b>45</b>      | Total no presencial. <i>Total non-face-to-face</i>           | <b>67,5</b>    |
| TOTAL presencial + no presencial <i>Total</i>                                                                                       |                |                                                              | <b>112,5</b>   |

(1) Actividad presencial a distancia es cuando un grupo sentado en un aula del campus sigue una clase por videoconferencia de forma síncrona, impartida por el profesor. *Distance face-to-face activity refers to a situation in which a group of students, seated in a classroom on campus, attends a class via live videoconference delivered by the instructor in real time.*

**7. Sistema y características de la evaluación****Assessment system and criteria**

| INSTRUMENTO/PROCEDIMIENTO<br>ASSESSMENT<br>METHOD/PROCEDURE | PESO EN LA<br>NOTA FINAL<br>WEIGHT IN FINAL<br>GRADE | OBSERVACIONES<br>REMARKS                                               |
|-------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------|
| Written exam                                                | 35%                                                  |                                                                        |
| Assignments                                                 | 60%                                                  | 2-4 Assignments. Oral presentation of the assignments may be required. |
| Participation in the activities developed in the classroom  | 5%                                                   |                                                                        |
|                                                             |                                                      |                                                                        |

**CRITERIOS DE CALIFICACIÓN ASSESSMENT CRITERIA**

- **Convocatoria ordinaria. First Exam Session (Ordinary)**
  - Written exam + assignments. A minimum global mark of 5.0 is required to pass.
- **Convocatoria extraordinaria<sup>(\*)</sup> Second Exam Session (Extraordinary / Resit) <sup>(\*)</sup>:**
  - The student can choose between two options: 1) the same criteria as in the ordinary exam, or 2) Practical + written exam with 100% weight on final mark
- **Convocatoria extraordinaria de fin de carrera<sup>(\*)</sup> Extraordinary exam for end of degree:**
  - El alumnado que se acoge a la convocatoria extraordinaria de fin de carrera será evaluado mediante una prueba global que permita acreditar la adquisición de las competencias y resultados. Incluyendo examen teórico y tarea de cálculo para realizar en clase.

**8. Consideraciones finales****Final remarks**

The use of artificial intelligence (AI) tools as support in the development of assignments, reports, and other assessable documents is authorized, provided that such use is clearly specified in each submission. Students must explicitly indicate which AI tools were used, as well as the type of assistance provided (for example, text generation, data analysis, programming, etc.), in order to ensure transparency and promote the ethical use of these technologies.

