Universidad de Navarra

***Transport Phenomena (Ing.Gr.)***
*Guía docente 2025-26*

# PRESENTACIÓN

**Breve descripción**:

In this course, students will learn the fundamentals of transport phenomena in biological systems. Specifically, momentum transport and mass transport will be analyzed, and to a lesser extent energy transport.

**Titulación (Módulo/Materia)**:

- Ingeniería Biomédica (Fundamentos de Biología/ Fenómenos de Transporte)

**Detalles**:

- **ECTS**: 4 ECTS
- **Curso, semestre**: 3.º curso, 1.º semestre
- **Carácter**: Obligatorio
- **Idioma**: English

**Profesores de la asignatura**:

- Aldazábal Mensa, Javier / Catedrático
- Aramburu Montenegro, Jorge / Profesor Titular

# RESULTADOS DE APRENDIZAJE (Competencias)

### INGENIERÍA EN INGENIERÍA BIOMÉDICA

CB2 - Que los estudiantes sepan aplicar sus conocimientos a su trabajo o vocación de una forma profesional y posean las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio.

CE2 - Conocer y comprender a diferentes niveles (micro y macroscópico) las bases de los procesos biológicos que tienen lugar en los organismos así como sus implicaciones fisiológicas.

# PROGRAMA

**Unit 1: Introduction to Transport Phenomena in Biological Systems**

--The role of transport processes in biological systems. --Definition of transport processes. --Relative importance of convection and diffusion. --Physiological transport systems: cardiovascular system, respiratory system, kidneys. --Exercises.

**Unit 2: Fluid Mechanics in Biological Systems**

--Introduction. --Fluid kinematics. --Conservation relations and boundary conditions. --Fluid statics. --Constitutive relations. --Laminar and turbulent flow. --Application of momentum balance to the flow induced by a sliding plate, the pressure-driven flow through a narrow rectangular channel, and the pressure-driven flow through a cylindrical tube (Hagen-Poiseuille's equation). --Rheology and blood flow. --Differential form of the equation of Conservation of Mass. --Differential form of the Conservation of Linear Momentum and the Navier–Stokes equations in 3D. --Integral form of the Conservation of Mass. --Integral form of the Conservation of Momentum. --Bernoulli's equation. --Exercises.

**Unit 3: Heat and Mass Transport in Biological Systems**

--Fundamentals of heat transfer and fundamental of mass transfer. --Mass transfer in convective systems. --Boundary layer and mass transfer in the interphase. --Fick's law. --Second Fick's law. --Scale-up of mass transfer. --Mass transfer in biological and pharmaceutical systems.

# ACTIVIDADES FORMATIVAS

The **dedication of 100-120 hours** (4 ECTS) to the course Transport Phenomena is distributed in the following educational activities:

- Clases presenciales teóricas: 22 h.
- Clases presenciales prácticas: 18 h.
- Trabajos dirigidos: 16 h.
- Tutorías: 1 h.
- Estudio personal: 42 h.
- Evaluación: 3 h.
- Elaboración y defensa del PFG: 0 h.

# METODOLOGÍAS DOCENTES

- Clases expositivas
- Clases en sala de informática
- Trabajo individual o en grupo, resolución de problemas e informes de laboratorio
- Entrevista personal con el profesor de una asignatura
- Estudio del estudiante basado en diferentes fuentes de información
- Realización de pruebas evaluadas

This course is divided into two parts: Part 1, lectured by Dr. Jorge Aramburu and Part 2, lectured by Dr. Javier Aldazábal.

Part 1 consists of Units 1 and 2. In this part, lectures include both theoretical sessions where problems/exercises are solved (*clases expositivas*) and practical sessions in the computer rooms where (*clases en sala de informática*) the theoretical concepts are applied in ANSYS Fluent examples. All the PowerPoint presentations that the lecturer uses during the lectures and the proposed problems for each unit are in Adi. In addition to attending the lectures, students work in a project (Project 1) (*trabajo individual o en grupo, resolución de problemas e informes de laboratorio*) using ANSYS Fluent. At the end of Part 1, students take a midterm exam (*realización de pruebas evaluadas*). Students should work on their own according to their ability to learn concepts and the skills needed to successfully fulfill the competences listed in section "Competencias". Furthermore, tutorials (*entrevista personal con el profesor de una asignatura*) are available to all students, meaning that students are welcome to approach the lecturer to ask any course-related questions.

Part 2 consists of Unit 3.

# EVALUACIÓN

**CONVOCATORIA ORDINARIA**

- **Intervención en clases, seminarios y clases prácticas**: 10%.
- **Evaluaciones parciales y finales**: 60%.
- **Trabajos individuales y/o en equipo**: 25%.
- **Prácticas de laboratorio**: 5%.

The maximum mark a student can get is 10/10. The mark is distributed as follows:

- Part 1 – Attendance to lab sessions: **5%**.
- Part 1 – Assignments during lab sessions: **5%**
- Part 1 – Project 1: **10%**

- Part 1 – Exam of Part 1: **30%**. Contents: Units 1 and 2. **This midterm exam cannot be repeated December**.
- Part 2 – Attendance: **5%**
- Part 2 – Individual assignments: **15%**
- Part 2 – Project 2: **30%**

**To pass the course,**

- **the overal mark must be greater than or equal to 5/10, AND**
- **the mark in Exam of Part 1 must be greater than or equal to 3/10.**

**CONVOCATORIA EXTRAORDINARIA**

- **Intervención en clases, seminarios y clases prácticas**: 10%.
- **Evaluaciones parciales y finales**: 60%.
- **Trabajos individuales y/o en equipo**: 25%.
- **Prácticas de laboratorio**: 5%.

If the mark in the *Exam of Part 1* is < 5/10, then it must be retaken, and the same criteria used in the regular assessment will be used.

If the mark *Exam of Part 1* is >= 5/10, then the lecturers will decide how to proceed. *Assignments*, *Project 1*, or *Project 2* will have to be resubmitted. Then, the same criteria used in the regular assessment will be used.

If a student is pursuing a 10/10, then *Exam of Part 1* must be retaken and *Project 1* and *Project 2* must be resubmitted, if any of their original mark is not 10/10. The same criteria used in the regular assessment will be used and two marks will be calculated: (i) one condisering all the items as in the regular assessment and (ii) another mark considering *Exam of Part 1* (37.5%), *Project 1* (12.5%), and *Project 2* (50%). The best of (i) and (ii) will be taken as the final mark.

**ATTENTION: Please note that any attempt at fraud, copying, plagiarism, or other irregular behavior constitutes a serious offense as outlined in Title IV, "Academic Disciplinary Rules for Students," within the University of Navarra's Code of Conduct.**

For further information on Assessment, please see the Assessment document in Adi.

# HORARIOS DE ATENCIÓN

**Dr Javier Aldazábal Mensa (jaldazabal@unav.es)**

- Edificio Miramón. Planta 0.
- Horario de tutoría:

**Dr Jorge Aramburu Montenegro (jaramburu@unav.es)**

- Despacho IG-104. Edificio Igara. Planta -1.
- Horario de tutoría: Students are more than welcome to approach the lecturer to ask any course-related question. Appointments will be made via email at jaramburu@unav.es. In general, no email will be answered on weekends and doutbs will not be solved by email.

# BIBLIOGRAFÍA

**Bibliografía básica**


- G.A. Truskey, F. Yuan, D.F. Katz. *Transport phenomena in biological systems* (2nd Ed.), Pearson, Upper Saddle River (NJ), 2010. Localízalo en la Biblioteca

- R.L. Fournier. *Basic transport phenomena in biomedical engineering* (3rd Ed.), CRC Press, Boca Ratón (FL), 2012. Localízalo en la Biblioteca


**Bibliografía complementaria:**


- R.B. Bird, Stewart, W.E. E.N. Lightfoot. *Transport phenomena.* (2nd Ed.) John Wiley & Sons Inc. 2006.
- R.B. Bird, Stewart, W.E. E.N. Lightfoot. *Transport phenomena.* (1st Ed.) John Wiley & Sons Inc. 1960.
- J. Crank. *The Mathematics of Diffusion.* (2nd Ed.). Clarendon Press. 1979.
- R.A. Peattie, R.J. Fisher, J.D. Bronzio, D.R. Peterson. Transport Phenomena in Biomedical Engineering: Principles and Practices. CRC Press. 2013.
- A.K. Datta. Biological and Bioenvironmental Heat and Mass Transfer. (1st Ed.) Marcel Dekker Inc. 2002.
- S.M. Becker, A.V. Kuznetsov. Heat Transfer and Fluid Flow in Biological Processes. (1st Ed.) Elsevier. 2015.
- B.K. Dutta. Mathematical Methods in Chemical and Biological Engineering. (1st Ed.) Taylor & Francis. 2017.
- A.V. Wouwer, P.Saucez, C. Vilas. Simulation of ODE/PDE Models with Matlab(R), Octave and Scilab: Scientific and Engineering Applications. (1st. Ed) Springer Cham. 2014.