Universidad Rey Juan Carlos

TEACHING GUIDE

BIOLOGICAL DYNAMIC SYSTEMS ANALYSIS

GRADO EN INGENIERÍA BIOMÉDICA (INGLÉS) (3º y 4º curso) (2374)

ACADEMIC YEAR 2026-27

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

Publication date: 02-07-2026

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

I.-Subject Identification	
Type	OBLIGATORIA
Teaching period	3 course, 1Q semester
Nº of credits	6
Language in wich the subject is taught	English

II.-Presentation

The student knows the approach to dynamic problems such as differential equations, knows the tools for their analysis, both analytical and computations. The examples used will have an approach oriented to study dynamic systems in biology, the typical physical processes in biological systems and in complex biological systems.

The course proceeds to develop, from the first principles of differential calculus, the analysis of systems of nonlinear differential equations, with a special emphasis on biological and biomedical models.
The concepts of one-dimensional flows (in a line) will be introduced and the concept of bifurcations will be introduced. Special emphasis will be placed on the geometric and qualitative interpretation of these systems. In this part we will conclude with the analysis of the dynamical system of the spruce budworm and how this simplified model gives us an understanding of the effects of a bifurcation on population dynamics. The practice to be carried out in the laboratory will be related to the dynamics of epidemics such as COVID 19.

III.-Learning outcomes

CG01 . Analyze and synthesize problems related to biomedical engineering, solve them and communicate them efficiently.
CB5 . That students have developed the learning skills needed to undertake further studies with a considerable degree of autonomy.
CE01 . Understand or acquire the principles of bioelectrical fundamentals, anatomy, physiology or pathophysiology needed to identify the most appropriate processing technologies for a given problem in biomedical engineering

- Key for degrees not adapted to RD 822/21: **CB** - basic competences, **CG** - generic competences, **CE** - specific competences, **CT** - transversal competences.
- Key for degrees adapted to RD 822/21: **CON** - knowledge, **COM** - competences, **HAB** - skills.

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

IV.-Contents

IV.A.-Syllabus

1. Overview

2. One-Dimensional Flows

2.1. Flows on the Line

2.1.1. Introduction
2.1.2. A Geometric Way of Thinking
2.1.3. Fixed Points and Stability
2.1.4. Population Growth
2.1.5. Linear Stability Analysis
2.1.6. Existence and Uniqueness
2.1.7. Impossibility of Oscillations
2.1.8. Potentials
2.1.9. Solving Equations on the Computer

2.2. Bifurcations

2.2.1. Introduction
2.2.2. Saddle-Node Bifurcation
2.2.3. Transcritical Bifurcation
2.2.4. Laser Threshold
2.2.5. Pitchfork Bifurcation
2.2.6. Overdamped Bead on a Rotating Hoop
2.2.7. Imperfect Bifurcations and Catastrophes
2.2.8. Insect Outbreak

3. Two-Dimensional Flows

3.1. Linear Systems

3.1.1. Introduction
3.1.2. Definitions and Examples
3.1.3. Classification of Linear Systems
3.1.4. LoveAffairs

3.2. Phase Plane

3.2.1. Introduction
3.2.2. Phase Portraits
3.2.3. Existence, Uniqueness, and Topological
3.2.4. Consequences
3.2.5. Fixed Points and Linearization
3.2.6. Rabbits versus Sheep
3.2.7. Conservative Systems
3.2.8. Reversible Systems
3.2.9. Pendulum
3.2.10. Index Theory

3.3. Limit Cycles

3.3.1. Introduction
3.3.2. Examples
3.3.3. Ruling Out Closed Orbits
3.3.4. Poincaré−Bendixson Theorem
3.3.5. Liénard Systems

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

3.3.6. Relaxation Oscillations
3.3.7. Weakly Nonlinear Oscillators
3.4. Bifurcations Revisited
3.4.1. Introduction
3.4.2. Saddle-Node, Transcritical, and Pitchfork
3.4.3. Bifurcations
3.4.4. Hopf Bifurcations
3.4.5. Oscillating Chemical Reactions
3.4.6. Global Bifurcations of Cycles
3.4.7. Hysteresis in the Driven Pendulum and Josephson Junction
3.4.8. Coupled Oscillators and Quasiperiodicity
3.4.9. Poincaré Maps

IV.B.-Training activities

Type	**Title**
Theoretical sessions	Labs
Individual work	Individual Research Work Tutoring
Theoretical sessions	Lectures
Resolution of exercises, problems, case studies	Problem Solving

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

V.-Student workload	
Theoretical sessions	20
Resolution of exercises, problems, case studies, etc.	20
Practical sessions in experimental, technological and clinical laboratories, fieldwork, etc.	16
Tests and/or exams	4
Academic tutorials	28
Related activities: conferences, seminars, etc.	20
Preparation of theoretical sessions and self-study	30
Preparation of practical tasks, exercises, case studies, projects, etc.	20
Preparation for tests and/or exams	22
Total student workload	180

VI.-Methodology and academic programme

Type	Period	Content
Practical sessions	Week 7 to Week 15	Two dimensional flows problem solving in the blackboard of selected exercises of the proposed homework for the approximate duration of an hour. All the supporting material will be published in Aula Virtual.
Practical sessions	Week 1 to Week 6	One dimensional flows problem solving in the blackboard of selected exercises of the proposed homework for the approximate duration of an hour. All the supporting material will be published in Aula Virtual.
Academic tutorials	Week 1 to Week 15	Tutoring and consultation on academic matters will be provided in the rooms of the respective professors.Tutoring and consultation on academic matters will be provided by means of the Microsoft Teams tool. It will be necessary to make a reservation by means of an email from the personal account of the student from the alumnos.urjc.es domain with the header [BDSA]

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

Tests and/or exams	Week 7 to Week 7	One dimensional flows Test. A synchronous present exam will take place.
Tests and/or exams	Week 16 to Week 16	Two Dimensional Flows Test. A synchronous present exam will take place.
Experimental and/or technological laboratories	Week 1 to Week 6	One dimensional Flows Labs. By using Matlab, selected examples of linear ODEs will be solved both by numerical and graphical methods for the approximate duration of an hour. All the supporting material will be published in Aula Virtual.
Experimental and/or technological laboratories	Week 7 to Week 15	Two Dimensional Flows Labs. By using Matlab, selected examples of linear ODEs will be solved both by numerical and graphical methods for the approximate duration of an hour. All the supporting material will be published in Aula Virtual.
Theoretical sessions	Week 1 to Week 6	Theoretical Lectures onone dimensional flows. Recommended reading material for a theoretical class of approximately one hour. All the supporting material will be published in Aula Virtual.
Theoretical sessions	Week 7 to Week 15	Theoretical Lectures on Two Dimensional Flows. Recommended reading material for a theoretical class of approximately one hour. All the supporting material will be published in Aula Virtual.

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

VII.-Assessment methods
The general assessment method is continuous as established in the *Regulation for the Assessment of Learning Outcomes* of Rey Juan Carlos University. All the assessment systems established in the degree report must be employed, except for those that have a minimum weight of 0%, which can be used by professors in the academic years they consider relevant. Each assessment system may be applied through one or more assessment activities, consistent with the system. No assessment activity can exceed individually 60% of the overall grade for the subject. The sum of non re-evaluable activities cannot exceed 40% of the overall grade for the subject and, in general, should not have an established minimum grade (except for practical activities in which, strictly speaking, the conditions of the ordinary call cannot be reproduced in the extraordinary call). Those students who do not manage to pass the subject in the ordinary call, or do not attend this first call, may attend the extraordinary call only for failed re-evaluable assessment activities. The distribution and characteristics of the assessment activities are described below.
VII.A.-Description and weight of the assessment activities

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

Continuous ordinary assessment:
The distribution and characteristics of the assessment tests are those described below. Only in exceptional case and for special reasons may the teacher add changes to the Guide. These changes will require the prior consultation with the Subject Head and the prior and explicit authorisation of the Degree Programme Coordinator, who will notify the Vice-Rector's office in charge of Academic Affairs of the modifications made. In any case, the changes proposed must take into account the stipulations of the verified report. In order for these changes to take effect, they must be duly communicated at the start of the course to the students using Aula Virtual.
The combination of activities that are not re-assessable cannot exceed 50% of the subject grade and, in general, cannot have a minimum grade (except for the case of laboratory or clinical work placements, where duly justified), and tests which exceed 60% of the subject weighting cannot be added.
Extraordinary assessment: Students who do not manage to pass the ordinary assessment, or who did not attend, will be subject to completion of an extraordinary assessment to verify their acquisition of the skills established in the guide, only for activities that are re-assessable.

Ordinary Call:
1. Evaluation of two partial exams (30% each). Revaluable. For the average of these two partial exams to be computed, a minimum grade of 4/10 is needed in each one and an average of the two tests equal to or greater than 5/10. If a score of less than 4/10 is obtained in the first quarter, the entire subject will be examined in January (second chance). In this second chance a total score of the January exam equal to or greater than 5/10 is needed to pass the subject.
2. Evaluation of deliveries of problems (6 problem sheets, one for each chapter, marks equally weighted) solved in Classroom (group, document plus presentation). Not revaluable (15% of the total). No minimum grade is necessary.
3. Evaluation of introductory research work on biomedical dynamical systems (group, document plus presentation). Not revaluable (15%). No minimum grade is necessary.
4. Tests on each topic (6 tests, one for each chapter, marks equally weighted) , carried out by the student in the Virtual Classroom (individual). Not revaluable (10%). No minimum grade is necessary.
Extraordinary Call:
1. June examination of the entire subject (regardless of the partial approved in the ordinary call) (60%). A minimum grade of 5/10 is required to pass.
Advanced Call:
1. June examination of the entire subject (regardless of the partial approved in the ordinary call) (60%). A minimum grade of 5/10 is required to pass.
Advanced Call:
2. Marks of the non-revaluable activities of the previous course will be used to computed only the final Advanced Call.
The student who wishes to opt for this assessment will have to get an academic exemption for the subject, which they will have to request from the Dean or Director of the Centre which teaches their course. An academic exemption may be granted where the subjects own characteristics allow for it.

VII.B. Assessment of students with academic exemption from class attendance

Having Academic Exemption from Class Attendance (DAAC) does not imply that students are automatically exempt from participating in the continuous assessment activities or in the training activities of compulsory attendance as established in the teaching guide. Once the exemption has been granted, students must contact the subject's teaching staff, who will propose the adaptations he/she may consider relevant, as long as they guarantee the acquisition and adequate assessment of the learning goals established. Students must maintain adequate communication with the teaching staff so that they may provide information on the dates for training and assessment activities, if these are not established in the programme and available for students at the time of achieving the exemption.
Subject with possibility of academic exemption: Yes.

VII.C. Review of assessment activities

In accordance with the Regulation for the Assessment of Learning Outcomes of Rey Juan Carlos University.

VII.D.-Students with a disability or special educational needs

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

In order to guarantee equal opportunities, non-discrimination, universal accessibility and academic success, students with disabilities or especial education needs may request curricular adaptations to follow their studies. These adaptations will be provided by the Unit of Attention to People with Disabilities of Rey Juan Carlos University, in accordance with the regulation which regulates the service for the Attention of People with Disabilities at the University. This Unit will issue a report for curricular adaptations, so that students with disabilities or special education needs must contact the service (at e-mail discapacidad.programa@urjc.es) in order to provide relevant information for different educational alternatives.

VII.E.-Academic behaviour, academic integrity and honesty

Rey Juan Carlos University is fully committed to the highest standards of academic integrity and honesty, so studying at the URJC means assuming and subscribing to the values of integrity and academic honesty set out in the University's Ethical Code. To support this process, the University has Rey Juan Carlos University's Academic Conduct Regulation as well as different tools (anti-plagiarism, supervision...) that offer a collective guarantee for the full development of these essential values.

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

VIII.-Teaching resources and materials
Basic bibliography
Nonlinear Dynamics and Chaos. With Applications to Physics, Biology, Chemistry and Engineering. Steven H. Strogatz. CRC Press (2015)
Consultation bibliography
Applied Differential Equations: The Primary Course. Vladimir A. Dobrushkin. CRC Press (2015)

IX.-Professors	
Name and surname	ANTONIO JOSÉ CAAMAÑO FERNÁNDEZ
E-mail address	antonio.caamano@urjc.es
Department	Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computación
Campus	Fuenlabrada
Category	Catedrático/a de Universidad
Academic degree	Doctor
Person responsible for the subject	Yes
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico
Number of quinquennia	4
Number of sexennia	4
No. of positive evaluations by Docentia	2
Name and surname	DAVID CASILLAS PÉREZ
E-mail address	david.casillas@urjc.es
Department	Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computación
Campus	Fuenlabrada
Category	Titular de Universidad
Academic degree	Doctor
Person responsible for the subject	No
Tutorial timetable	Para consultar las tutorias póngase en contacto con el/la profesor/a a través de correo electrónico

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.

Number of quinquennia	1
Number of sexennia	1
No. of positive evaluations by Docentia	1

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 14/11/2026 18:54 | Hash: 08bf3ec411ba99a20c2fb165b2b071ee.