Universidad Rey Juan Carlos

# TEACHING GUIDE

# Mathematical Methods in Biomedical Engineering

## GRADO EN INGENIERÍA BIOMÉDICA (INGLÉS) (1º y 2º curso)

## ACADEMIC YEAR 2026-27

Q2803011B UNIVERSIDAD REY JUAN CARLOS
Fecha firma: 09/11/2026 22:24 | Hash: 208fff0262fda6980b5d18b0dcd2b084.

Publication date: 04-07-2026

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| I.-Subject Identification | |
|---|---|
| **Type** | FORMACIÓN BÁSICA |
| **Teaching period** | 1 course, 2Q semester |
| **Nº of credits** | 6 |
| **Language in wich the subject is taught** | English |

## II.-Presentation

**Vectorial Calculus** is part of a fundamental base for the construction of designs, procedures, methodologies, tools and algorithms present in a considerable part of the specific matters that a graduated in biomedical engineering will study during their formation process.
The main formative goals of the subject of Mathematical Methods for Bioengineering are:
•Highlight the importance of the **analysis** and **multivariate calculus** in the design, description and study of usual systems in engineering and biomedicine.
•Provide the student with the capacity to define and understand multivariate models and perform efficient calculations, with the goal of solving engineering problems about this kind of systems, with special interest in biomedical applications.
**Previous requirements** and **recommendations:** it is convenient for the student to have coursed the subjects of **Calculus** and **Algebra** so that they possess knowledge about single-variable real functions, limits, continuity, derivability, sequences and function sequences, calculation of primitives, integration, vector spaces, linear applications and linear systems.
In order to facilitate the overcoming of the subject and reaching the formative goals, the students are encouraged to **read the contents** of each lecture **beforehand**, the **completion** of the **activities** proposed in class and the **resolution** of **problems** proposed in the recommended bibliography, as well as the attendance to mentor meetings with the teacher whenever necessary.

## III.-Learning outcomes

COM16. Ability to identify, formulate and solve engineering problems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to recognise the importance of non-technical ¿societal, health and safety, environmental, economic and industrial ¿ constraints. (EURACE 2.2)
CON20. Knowledge and understanding of the mathematics, computation and other basic sciences underlying their engineering specialisation, at a level necessary to achieve the other programme outcomes. (EURACE 1.1)
HAB03. Ability to solve mathematical problems that may arise in engineering. Proficiency in applying knowledge of linear algebra, geometry, differential geometry, differential and integral calculus, differential equations and partial differential equations, numerical methods, numerical algorithms, statistics, and optimization.
HAB17. Ability to analyse complex engineering products, processes and systems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to correctly interpret the outcomes of such analyses. (EU-RACE 2.1)

- 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.

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## IV.-Contents

### IV.A.-Syllabus

**-Thematic Block I: Introduction:**

•*Lesson 1: Geometry in the Euclidean Space: Vectors*

Vectors in two and three dimensions. Dot Product. Cross Product. Equations for Planes and Distances. Geometry in n-dimensions. New coordinate systems.

**-Thematic Block II: Differentiation in Several Variables:**

•*Lesson 2: Differentiation in Several Variables*

Functions of Several Variables. Surface Graphing. Limits. Definition of Derivative. Differentiability. Higher-Order Partial Derivatives. The Chain Rule. Directional Derivatives. The Gradient.

•*Lesson 3: Vector-Valued Functions*

Parametrized Curves. Arclength and Introduction to Differential Geometry. Introduction to Vector Fields. Gradient, Divergence, Curl and Del (Nabla) Operator.

•*Lesson 4: Higher Order Derivatives: Maxima and Minima in Several Variables*

Differentials and Taylor's Theorem. Extrema of Functions. Lagrange Multipliers. Some Applications of Extrema.

**-Thematic Block III: Integration in Several Variables:**

•*Lesson 5: Multiple Integration*

Areas and Volumes. Double Integrals. Changing the Order of Integration. Triple Integrals. Change of Variables. Applications of Integration.

•*Lesson 6: Line Integrals*

Scalar and Vector Line Integrals. Green's Theorem. Conservative Vector Fields.

•*Lesson 7: Surface Integrals and Vector Analysis*

Parametrized Surfaces. Surface Integrals. Integral Theorems of Vector Analysis: Stoke's and Gauss's Theorems.

### IV.B.-Training activities

| Type | Title |
|---|---|
| Theoretical sessions | Lectures |
| Resolution of exercises, problems, case studies | Problem resolution |

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| V.-Student workload | |
|---|---|
| Theoretical sessions | 30 |
| Resolution of exercises, problems, case studies, etc. | 18 |
| Practical sessions in experimental, technological and clinical laboratories, fieldwork, etc. | 8 |
| 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 |
|---|---|---|
| Academic tutorials | Week 1 to Week 17 | After the appointment via email. There won't be tuition in the 48 hours previous to any written test. |
| Tests and/or exams | Week 7 to Week 17 | Partial and Final exams. |
| Theoretical sessions | Week 1 to Week 15 | A detailed explanation of the fundamental concepts and problems followed in the subject. |
| Experimental and/or technological laboratories | Week 3 to Week 15 | Realization of practices with Python |
| Resolution of exercises, problems, case studies | Week 1 to Week 15 | Student work with complementary material, problems and solutions. |

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## 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

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**Continuous ordinary assessment:**
The distribution and characteristics of the assessment tests are those described below. Only in exceptional cases 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 reassessable 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 evaluation**
The ordinary evaluation of the subject basically consists of a continuous evaluation which has three differentiated parts:
1) **Laboratory/exercises: 10% of the final mark.**
To facilitate the understanding of the subject, throughout the course, a series of exercises and practices (laboratory) will be proposed, usually coinciding with the end of each block. Completing the activities and delivering the corresponding reports with the obtained results is individual and **mandatory**. This activity is **not repeatable**. The laboratory reports delivered late or delivered in previous academic years will not be considered. The ponderation of the activity only affects the final mark once the written tests are passed. There is **no minimum grade** for this activity.

2) **First written test: 45% of the final mark.**
The first written test will include the contents of the first lessons defined in the section Contents. This test is mandatory**, re-assessable,** and **removes contents**. A **minimum mark** of **5/10** is required.

3) **Second written test: 45% of the final mark.**
In this second mandatory written test, the rest of the contents of the subject will appear. This test is **mandatory, reassessable,** and **removes contents**. A **minimum mark** of **5/10** is required.

**Sumarizing**

| Activity | Weigth | Minimum Mark | Re-assessable |
|---|---|---|---|
| **Laboratory Exercise** | 10% | No | No |
| **First written test** | 45% | 5 | Yes |
| **Second written test** | 45% | 5 | Yes |

**Extraordinary Evaluation**
In the extraordinary evaluation, those evaluation activities classified as re-assessable in the ordinary evaluation will be repeated, also keeping all their characteristics. Therefore, the extraordinary evaluation will consist of **two parts**, corresponding to the reevaluation of the **two written tests**, which will have the same weight and the same minimum note specified in the ordinary evaluation. In this way, to pass the course, each student must complete and pass the reevaluation test or tests corresponding to those written tests that you have not passed in the ordinary evaluation period.
•Revision of the score of the written tests.
The following considerations are important in the revision of the qualification of exercises and practices:
1) The time dedicated to the revisions of the marks is not oriented to the resolution of doubts, but to the resolution of errors or discrepancies in marking.
2) The student must bring to the revision the resolution of the test.
3) To solve doubts about the problems or questions introduced in the tests, the procedure will be the same as with the rest of the doubts throughout the course, with the student asking for tuition.
4) In the case of any kind of plagiarism, in any kind of test or exercise which counts on the final mark, the procedure followed will be the one stipulated in the "Normative of Academic Conduct of the University Rey Juan Carlos" ("Normativa Sobre Conducta Académica de la Universidad Rey Juan Carlos").
**Advance Evaluation Call**

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According to the current normative, students who have a justified need to take the Advanced Evaluation call will submit two written tests, the first covering the first block of the subject, and the second covering the second part of the subject. The final mark of the subject will be the mean value of the mark of each exam; each exam counts **50%** towards the final mark**.**
Students who wish 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 subject's own characteristics allow for it.

**Review of assessment tests**

In accordance with the exam appeal regulations of the Universidad Rey Juan Carlos.

**Students with a disability or special educational needs**

Curricular adaptations for students with a disability or special educational needs will be determined by the Disabled Students Support Department, in accordance with the regulations governing the Disabled Students Support service, approved by the Universidad Rey Juan Carlos Council, in order to guarantee equal opportunities, inclusive treatment, universal accessibility and a greater guarantee of academic success. For this purpose, this Department will have to issue a curricular adaptation report; students with disabilities or special educational needs must contact the Department to analyse the different alternatives together.

**Academic behaviour, academic integrity and honesty**

The Universidad Rey Juan Carlos is completely committed to the highest standards of academic integrity and honesty. Therefore, studying at the URJC means you accept and agree to the academic integrity and honesty values described in the University's Code of Ethics. In order to monitor this procedure, the University has Regulations on academic behaviour at the Universidad Rey Juan Carlos and uses different tools (anti-plagiarism, supervision?) which provide a collective assurance that these essential values are completely developed

**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**

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.

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| VIII.-Teaching resources and materials |
|---|
| **Basic bibliography** |
| Vector Calculus (4th Edition), **Susan Jane Colley**, Ed. Pearson, 2012<br>Vector Calculus (6th Edition), **Jerrold E. Marsden and Anthony Tromba**, Ed. W. H. Freman and Company, 2011 |
| **Consultation bibliography** |
| Schaum Vector Analysis, **Murray R. Spiegel**, Ed. McGraw-Hill Education, 1959<br>Biocalculus, **James Stewart y Troy Day**, CENGAGE Learning, 2015 |
| Python resources: https://github.com/python<br>Mathematica resources https://www.wolfram.com/mathematica/<br>MIT course on Multivariate Calculus: https://ocw.mit.edu/courses/mathematics/18-022-calculus-of-several-variablesfall2010/index.htm |

| IX.-Professors | |
|---|---|
| **Name and surname** | JAVIER ALEJANDRO QUINTERO ROBA |
| **E-mail address** | javier.quintero@urjc.es |
| **Department** | Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computación |
| **Campus** | Fuenlabrada |
| **Category** | Profesor/a Ayudante Doctor/a |
| **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** | 1 |
| **Number of sexennia** | 0 |
| **No. of positive evaluations by Docentia** | 0 |

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