



## Course guide

# 820009 - CNED - Numerical Calculus. Differential Equations

Last modified: 14/06/2023

**Unit in charge:** Barcelona East School of Engineering  
**Teaching unit:** 749 - MAT - Department of Mathematics.

**Degree:** BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Compulsory subject).

**Academic year:** 2023    **ECTS Credits:** 6.0    **Languages:** Catalan, Spanish

### LECTURER

---

**Coordinating lecturer:** M. JOSÉ JIMÉNEZ JIMÉNEZ - JOSE JAVIER MUÑOZ ROMERO

**Others:** Primer quadrimestre:  
ENRIC AMADO VICENTE - Grup: T11, Grup: T12  
ADRIÀ DOMINGO GIMENEZ - Grup: T31, Grup: T32  
RAIMON ELGUETA MONTÓ - Grup: T31, Grup: T32  
ALFONSO ESCOBOSA FERNANDEZ - Grup: T31, Grup: T32  
M. JOSÉ JIMÉNEZ JIMÉNEZ - Grup: M11, Grup: M12, Grup: M21, Grup: M22  
ALVARO MARTIN LLOPIS - Grup: T11, Grup: T12, Grup: T21, Grup: T22  
NURIA PARES MARINE - Grup: M11, Grup: M12, Grup: M21, Grup: M22  
MARGARITA TORRE ALCOCEBA - Grup: T21, Grup: T22, Grup: T31, Grup: T32

Segon quadrimestre:  
EDWIN SANTIAGO ALFÉREZ BAQUERO - Grup: M42, Grup: M61  
ENRIC AMADO VICENTE - Grup: T11, Grup: T12  
KEVIN IVAN BARRERA LLANGA - Grup: M41, Grup: M62, Grup: M71, Grup: M72  
ADRIÀ DOMINGO GIMENEZ - Grup: M71, Grup: M72  
MARIONA GONZÁLEZ ESTEVE - Grup: T11, Grup: T12  
M. JOSÉ JIMÉNEZ JIMÉNEZ - Grup: M31, Grup: M32  
PERE LOPEZ BROSA - Grup: M21, Grup: M22, Grup: M51, Grup: M52  
ALVARO MARTIN LLOPIS - Grup: T21, Grup: T22, Grup: T31, Grup: T32  
JOSE JAVIER MUÑOZ ROMERO - Grup: M11  
CÉCILIA OLIVESI - Grup: M11  
NURIA PARES MARINE - Grup: M11, Grup: M31, Grup: M32  
JOAN QUINTANA COMPTE - Grup: M41, Grup: M42, Grup: M61, Grup: M62  
MARGARITA TORRE ALCOCEBA - Grup: T11, Grup: T12, Grup: T21, Grup: T22, Grup: T31, Grup: T32  
ROGER VALDÉS I MARTÍN - Grup: M21, Grup: M22, Grup: M51, Grup: M52

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

### Specific:

2. 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.

### Transversal:

1. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

## TEACHING METHODOLOGY

Apart from the 6 hours per week in the classroom, self-study must last an average of 9 hours per week (40% of the total work at class and 60% of individual work).

## LEARNING OBJECTIVES OF THE SUBJECT

Unit 1: Introduce the students to computer simulation explaining its capabilities, potential and limitations. Programming of basic numerical algorithms. Correct and judicious use of basic numerical methods. Ability to choose the appropriate method for different engineering applications.

Unit 2: State, analyze and numerically and analytically solve ordinary differential equations. Physical interpretation of ode's.

Unit 3: Use of integral transforms in engineering applications.

Unit 4: State, analyze and numerically and analytically solve partial differential equations. Physical interpretation of pde's.

## STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours small group	15,0	10.00
Hours large group	45,0	30.00

**Total learning time:** 150 h

## CONTENTS

### Unit 1: Basics of numerical calculus

#### Description:

- 1.1. Numbers and errors. Finite arithmetic storage. Absolute error, relative error, truncation error. Correct significant digits.
- 1.2. Roots of functions. Bisection, Newton and secant methods. Convergence criteria. Convergence rates.
- 1.3. Interpolation and approximation. Pure interpolation. Least squares interpolation. Linear spline.
- 1.4. Numerical integration. Simple and composite rectangle approximation. Simple and composite trapezoidal rule. Simple and composite Simpson rule. Deduction of the error term and order of convergence of the different methods.

**Full-or-part-time:** 67h 15m

Theory classes: 18h

Laboratory classes: 9h 30m

Self study : 39h 45m



## Unit 2: Ordinary differential equations

### Description:

- 2.1. Ordinary differential equation of first order. Separable ordinary differential equations. Linear first order differential equations.
- 2.2. Numerical methods for ode's: Euler and Runge-Kutta 4.
- 2.3. Linear differential equations of order 2 with constant coefficients. Undetermined coefficients method. Variation of constants method.

**Full-or-part-time:** 36h 15m

Theory classes: 12h

Laboratory classes: 2h 30m

Self study : 21h 45m

## Unit 3: Integral transforms and solution of ordinary differential equations

### Description:

- 3.1. Laplace transform and its properties. Invers Laplace transform. Solution of ordinary differential equations and systems of ordinary differential equations.
- 3.2. Fourier series.

**Full-or-part-time:** 27h 45m

Theory classes: 9h

Laboratory classes: 1h 30m

Self study : 17h 15m

## Unit 4: Partial differential equations

### Description:

- 4.1. Introduction to partial differential equations. Motivation.
- 4.2. Equations of mathematical physics. Boundary conditions.

**Full-or-part-time:** 18h 45m

Theory classes: 6h

Laboratory classes: 1h 30m

Self study : 11h 15m

## GRADING SYSTEM

First exam: 30%

Second exam: 40%

Matlab Laboratory: 25%

Generic competence: 5%

Students can pass the course through the continuous assessment based on two exams (a first mid course exam and a second exam during the period fixed in the academic calendar of the school devoted to the final exams) and the delivery of laboratory assessments.

Finally, as detailed in the academic normative of the EEBE, a reevaluation exam will take place (excluding the Matlab Laboratory exam and the Generic Competence). To be able to do the reevaluation exam, the student has to attend to all the evaluation exams of the subject and its mark, N, for the part which can be reevaluated has to be such that  $3.0 > N \geq 3.0$   
<https://eebe.upc.edu/ca/estudis/normatives-academiques/documents/eebe-normativa-avaluacio-i-permanencia-18-19-aprovat-je-2018-06-13.pdf>



## EXAMINATION RULES.

---

In the two exams it will be allowed to use scientific calculators, but NEITHER PROGRAMMABLE NOR GRAPHING calculators .

## BIBLIOGRAPHY

---

### Basic:

- Huerta, Antonio; Sarrate, Josep; Rodríguez-Ferran, Antonio. Métodos numéricos : introducción, aplicaciones y programación [on line]. Barcelona: Edicions UPC, Universitat Politècnica de Catalunya, 1998 [Consultation: 21/04/2020]. Available on: <http://hdl.handle.net/2099.3/36258>. ISBN 8483012650.
- Arias, I. [et al.]. Cálculo avanzado para ingeniería : teoría, problemas resueltos y aplicaciones [on line]. Barcelona: Edicions UPC, 2008 [Consultation: 21/04/2020]. Available on: <http://hdl.handle.net/2099.3/36849>. ISBN 9788483017609.
- Zill, Dennis G.; Cullen, Michael R. Ecuaciones diferenciales con problemas de valores en la frontera. 7ª ed. México, D.F. [etc.]: Cengage Learning, 2009. ISBN 9789708300384.
- Vázquez, Luís [et al.]. Métodos numéricos para la física y la ingeniería. Madrid: McGraw Hill, cop. 2009. ISBN 9788448166021.

### Complementary:

- Çengel, Yunus A.; Palm, William J. Ecuaciones diferenciales : para ingeniería y ciencias. México [etc.]: McGraw-Hill, 2014. ISBN 9786071509895.
- Burden, Richard L.; Faires, J. Douglas. Análisis numérico. 7ª ed. México [etc.]: International Thomson, cop. 2002. ISBN 9706861343.
- Chapra, Steven C.; Canale, Raymond P. Métodos numéricos para ingenieros. 6ª ed. México [etc.]: McGraw-Hill, cop. 2011. ISBN 9786071504999.
- Hoffman, Joe D. Numerical methods for engineers and scientists. 2nd ed. New York [etc.]: Marcel Dekker, cop. 2001. ISBN 0824704436.
- Recktenwald, Gerald W. Numerical methods with MATLAB : implementations and applications. Upper Saddle River: Prentice Hall, cop. 2000. ISBN 0201308606.
- Zill, Dennis G. Ecuaciones diferenciales con aplicaciones de modelado. 9ª ed. México, D.F. [etc.]: International Thomson, cop. 2009. ISBN 9789708300551.