Guia docent [Codi UD] – [Sigles UD] – Numerical analysis and modelling

Responsable Unit:	Escola d'Enginyeria de Barcelona Est			
LEcturing Unit:	Mathematics			
Curs	2025	**Credits**		6
Languages	Catalan, Spanish			

PROFESSORS

Coordinators:	José J. Muñoz; María José Jiménez Jiménez;
Others:	Ángeles Carmona; Andrés M. Encinas;

PREVIOUS REQUIREMENTS

Calculus in one and several variables; Linear algebra; Differential Equations, Programming

LECTURING METHODOLOGY

· AF.1.- Exposición de contenidos teóricos.
· AF.2.- Resolución de ejercicios, problemas y casos.
· AF.4.- Discusión de problemas o artículos científicos.
· AF.6.- Realización de trabajo individual y cooperativo.
· AF.7.- Sesiones en laboratorios informáticos o de simulación

OBJECTIUS D'APRENENTATGE DE L'ASSIGNATURA

Capacity for identifying and propose mathematical models in biomedical engineering.
Understand and manipulate the numerical methods for solving the models in biomedical applications.
Numerically solve differential equations and equations with partial derivatives for problems in epidemiology, reaction-diffusion, networks of neurons and scattering.

HORES TOTALS DE DEDICACIÓ DE L'ESTUDIANTAT

Tipus	Hores	Percentatge
Hours of guided activities	24,0	16.00 %
Hours of large groups	24,0	16.00 %
Hours of small groups	0,0	0.00 %
Hours of autonomous learning	102,0	68.00 %
Total Dedication: 150h		

CONTINGUTS

Subject 1: Modelling dynamical systems.

Description: Modelling and solving dynamical systems for predicting temporal evolution.
-Topic 1. Non-linear systems of equations: Newton-Raphson and quasi-Newton. Applications to optimisation.
-Topic 2. Numerical methods for ODEs: Euler and Runge-Kutta. Explicit and implicit methods. Stability and conditioning.
-Topic 3. Application to epidemiological models (SIR). Population dynamics and networks of neurons.

Related Activities:
Implementation of simple models with two and three variables.
Application to epidemiological problems (SIR model: Sane-Infected-Recovered). Simulation of scenarios and actuations.
Application to dynamics systems of neurons mad synaptic signalling.

Dedication: total hours
Large group/Theory: 6h
Tutorials: 6h
Autonomous Learning: 25h

Subject 2:	Optimization and parameter fitting

Description: Understand and solve optimisation problems numerically. Fitting of parameters from experimental data.
- Topic 1 Optimisation algorithms. Optimality conditions, gradient and descent methods, line search and genetic algorithms.
- Topic 2 Fitting methods: least-square, maximum likelihood.
- Topic 3 Case studies: parameter fitting in tumour growth problems and viscoelastic materials.

Related Activities:
Optimisation of pharmaco-kinetic model and characteristic time in viscoelastic tissues.

Dedication: total hours
Large group/Theory: 6h
Tutorials: 6h
Autonomous Learning: 25h

Subject 3:	Linear Partial Differential Equations

Description: Modelling diffusion, pollution and thermal problems in biology.
- Topic 1 Classification and types of Boundary Value Problems: diffusion equations in statics. Boundary conditions.
- Topic 2 Finite difference methods. Finite element methods.
- Topic 3 Transient problems. Numerical resolution.

Related Activities: Application to diffusion and pollution problems.

Dedication: total hours
Large group/Theory: 6h
Tutorials: 6h
Autonomous Learning: 25h

Subject 4:	Reaction-diffusion models and scattering

Description: Understand, model and solve spatio-tmeporal problmes in biology.
- Topic 1. Examples of reaction-diffusion. Stability. Application to Turing patterns.
- Topic 2. Scattering problems. Inverse problems and tomography problems.

Related Activities: Application to image analysis problems, and pattern emergence in growth.

Dedication: total hours
Large group/Theory: 6h
Tutorials: 6h
Autonomous Learning: 25h

EVALUATION SYSTEM

Notes of Tutorials (T) = 30%
Nota de Course Work (CW) = 30%
Exam Final (FE) = 40%
Final mark (FM)= 0.30*T + 0.30*WT+ 0.40*FE

Especification
1. Tutorials (T) will be in computer room, following guided exercises that will be handed out at the end of the session. These exercises can be individual or in group depending on the topic.
2. Course Works (CW) maybe completed in group, and will be evaluated in oral presentation and with a written report. The mark will take into account both evaluations.
3. Final exam (FE) will consist in equations related to ach one of the topics, combining theoretical and practical concepts related to the applications.
4. There will be no re-evaluation exam.

BIBLIOGRAPHY

Basic:

[1] Ascher, U. M., Petzold, L. Computer methods for ordinary differential equations and differential algebraic equations, SIAM, 1998.
[2] Murray, J. D. Mathematical biology, Vol II , Springe. 2002-03.
[3] Nocedal, J, Wright, S.J. Numerical Optimization, Springer, 2006.
[4] Haberman, R. Ecuaciones en derivadas parciales con series de Fourier y problemas de contorno. Prentice Hall, 2003.
[5] Johnson, C. Numerical Solution of Partial Differential Equations by the Finite Element Method. Dover publications, 2009.

Complementary:

[6] Iserles, A. A First Course in the Numerical Analysis of Differential Equations. Cambridge Texts in Applied Mathematics, 2008.

RESOURCES
Other resources:
Course material available in ATENEA