2020/2021

Numerical Methods and Optimisation

Code: 104848
ECTS Credits: 6

Degree	Type	Year	Semester
2503852 Applied Statistics	FB	2	1

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: catalan (cat)

Some groups entirely in English: No

Some groups entirely in Catalan: Yes

Some groups entirely in Spanish: No

Teachers

Bogdan Vasile Crintea

Prerequisites

It is recommended to have passed the following courses: Àlgebra Lineal, Càlcul 1 and Càlcul 2.

Objectives and Contextualisation

This course will provide students the basic numerical methods to solve real problems which arise from science and mainly from applied statistics.

The purpose of the course is that the students learn the mathematical foundations of the methods, their range of applicability and the type of errors that should be expected. The student should also be able to recognize the problems whose solution requires the use of a numerical method, and to apply a proper method to get an approximate solution in an efficient way.

The student shoud also be able not only to use a programming language (R,...) to implement and test simple algorithms, but to work with the functions provided by the correspondig software.

Competences

- Calculate and reproduce certain mathematical routines and processes with agility.
- Critically and rigorously assess one's own work as well as that of others.
- Make efficient use of the literature and digital resources to obtain information.
- Select and apply the most suitable procedures for statistical modelling and analysis of complex data.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
- Use quality criteria to critically assess the work done.
- Use software for statistical analysis, numerical and symbolic analysis, graphic visualisation, optimisation or others, to solve problems.

Learning Outcomes

1. Calculate and study extrema of functions.
2. Compare the respective advantages and disadvantages of analytic methods and numerical methods.
3. Critically assess the work done on the basis of quality criteria.
4. Make effective use of references and electronic resources to obtain information.
5. Master the basic language and tools of linear algebra.
6. Reappraise one's own ideas and those of others through rigorous, critical reflection.
7. Recognise the usefulness of mathematical methods (calculus, algebra, numerical methods) for optimisation.
8. Select and use suitable software to solve problems in algebra, calculus and numerical calculation.
9. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
10. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
11. Use numerical methods to solve problems in algebra and calculus.

Content

1. Errors

Floating point arithmetic. Propagation of errors.

Conditioning of a problem.

2. Numerical Linear Algebra

LU decomposition. Perturbation analysis.

QR decomposition. Applications.

Singular value decomposition. Applications.

3. Numerical Solution of Nonlinear Equations

One variable equations: Fixed point methods. Newton-Raphson's method.

Methods for systems of nonlinear equations.

4. Polynomial interpolation

Lagrange polynomial. Divided differences.

Error estimate.

5. Unconstrained Optimitzation

One dimensional minimization.

Line search methods, gradient, Newton.

Methods without derivatives.

6. Constrained Optimitzation

The penalty method.

Augmented Lagrangian method.

7. Numerical Integration

Trapezoidal and Simpson's rules. Monte Carlo method.

Methodology

In the theoretical lectures the teacher will explain the mathematical foundations and basic properties of the numerical methods and will present several illustrative examples.

Different lists of exercises will be proposed so that the student can practice and learn the contents of each topic. In the problem lectures the teacher will work on the lists of exercises, will solve the doubts of the students and will discuss and solve the exercises.

Each computer session will have a script associated. In the computer sessions the student will do the work proposed in the correspondig script under the supervison of the teacher. It is convenient that before the session the student reads carefully the script in order to know the goal of the computer session and the numerical methods to be used. The student must attend the computer sessions.

All the course material will be posted on the Virtual Campus.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problems	14	0.56	6, 3, 1, 5, 10, 9, 7, 4, 11
Theory	26	1.04	6, 3, 1, 5, 10, 9, 7, 4, 11
Type: Supervised			
Computer sessions	12	0.48	6, 3, 1, 2, 8, 10, 9, 11
Type: Autonomous			
Computer work	21	0.84	6, 3, 1, 2, 8, 9, 7, 4, 11
Exercises	35	1.4	6, 3, 1, 5, 9, 7, 4, 11
Study	32	1.28	6, 3, 1, 5, 10, 9, 7, 4, 11

Assessment

The course will be evaluated continuously through the following activities:

- one mid-term exam, whose score is denoted by P
- computer work, whose score is denoted by PR
- a final exam, denoted by F

If F is greater than or equal to 3, the score by continuous assessment, N1, will be obtained from

N1 = 0.50 F + 0.30 P + 0.20 PR

If N1 is greater than or equal to 5, the final score is N1. Otherwise the student may attend a recovery exam if the following requirements are satisfied.

To participate in the recovery, the students must have previously been evaluated in a set of activities whose weight equals to a minimum of two thirds of the total grade of the subject or module. Therefore, students will obtain the «Non evaluable» qualification when the assessment activities carried out have a weigh of less than 67% in the final grade.

If R denotes the score of the recovery exam, then the final grade is

N2= 0.80 R + 0.20 PR

We remark that the score of the computer work, PR, can not be recovered.

The repeating students will have to do the same assessment activities as new entry students.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Computer work	20%	2	0.08	3, 1, 2, 8, 10, 7, 4, 11
Final exam	50%	3	0.12	6, 1, 2, 5, 10, 9, 11
Mid-term exam	30%	2	0.08	6, 1, 2, 5, 10, 9, 11
Recovery Exam	80%	3	0.12	6, 1, 2, 5, 10, 9, 11

Bibliography

A. Aubanell, A. Benseny i A. Delshams, *Eines bàsiques de Càlcul Numèric*, Manuals de la UAB, 1992.

R.L. Burden i J.D. Faires, *Numerical Analysis*, Brooks Cole Publishing, 2008.

G. Dahlquist i À. Björck, *Numerical Methods*. Prentice Hall, Englewood Cliffs, N.J., 1974.

D.E. Luenberger, Y. Ye, *Linear and non linear Programming*. Springer, 2008.

J. Nocedal i S.J. Wright. *Numerical Optimization.* Springer, 2006 (e-book Biblioteca UAB).

A. Quarteroni, F. Saleri, P. Gervasio. *Scientific Computing with MATLAB and Octave*. 4a edition, Springer 2014 (e-book, Biblioteca UAB).