# Math 6371-01 (Spring 2020)
# Numerical Analysis

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**Texts**

Numerical Mathematics by Alfio Quarteroni, Riccardo Sacco & Fausto Saleri, Springer, Second Edition (ISBN-10: 3642071015, ISBN-13: 978-3642071010)
The Matlab scripts for the examples in the second edition of the book can be downloaded as a tarred gzip file: http://mox.polimi.it/it/progetti/pubblicazioni/qss/programs_QSS_en.tar.gz

**Objectives**

This course is the second part of a two-course series meant to introduce Ph.D. students in mathematics to the fundamentals of numerical mathematics. The course provides the foundation of numerical methods, the analyze of their basic properties (stability, accuracy, and computational complexity), and demonstrates their performances on examples.

**Prerequisites**

Graduate standing or consent of instructor. Students should have had a course in Linear Algebra and an introductory course in analysis. Familiarity with Matlab or experience with compiled languages (e.g., Fortran, C, C++) is also required.

**Course Policies and Procedures**

<u>Grades</u>: Homework (40 percents), Exams (60 percents)

<u>Exams</u>: All three Exams will be given in class (one hour and half) and will be open-book, open-note.

<u>Homework</u>: There will be regular assignments. The assignments will be both computational and theoretical. A theoretical home assignment is due in one week after it is assigned in the class. A computational home assignment due dates may vary.

**Course Outline**

This is only a tentative agenda for the lectures. Adjustments can be made as we go along. Those who don't feel confident in there programming skills I recommend to play with MATLAB and consult, for example, the text Scientific Computing with MATLAB and Octave by A. M. Quarteroni & F. Saleri, Springer (any edition).

**Polynomial interpolation and Approximation theory**.

Lecture 1: Lagrange interpolation and interpolation error.

Lecture 2: Stability of polynomial interpolation.

Lecture 3: Newton form of interpolation polynomials, divided differences.

Lecture 4: Hermitian interpolation.

Lecture 5: Approximation by splines.

Lecture 6: Chebyshev polynomials and their properties, an application in polynomial interpolation.

Lecture 7: Best approximation in a vector space.

Lecture 8: The polynomial of best approximation and least-square approximations.

Exam I.

**Discrete transformations and Numerical integration**.

Lecture 9: Discrete Fourier Transform, Gibbs Phenomenon and FFT.

Lecture 10: Wavelets and Discrete Wavelet Transform.

Lecture 11: Quadrature formulae and interpolatory quadratures.

Lecture 12: Composite quadrature formulae.

Lecture 13: Orthogonal polynomials and Gaussian quadratures.

Lecture 14: Richardson extrapolation and automatic integration.

Lecture 15: Singular integrals, multidimensional integrals.

**Finite differences and numerical solution of ODE**.

Lecture 16: Difference equations

Lecture 17: The Cauchy problem and one-step numerical methods

Lecture 18: Runge-Kutta methods and time step control

Exam II.

**ODE cont. and two-point boundary value problems**.

Lecture 19: Multistep methods and stability analysis for the Cauchy problem.

Lecture 20: Regions of stability. Stiff systems of ODE.

Lecture 21: Finite difference methods for two-point b.v.p. Approximation, stability, convergence.

Lecture 22: Stability analysis and maximum principle.

Lecture 23: Galerkin method for two-point b.v.p.

Lecture 24: Finite element method and error estimate.

Lecture 25: A quick glance at the multi-dimensional case.

Exam III.