

## IS1240

### High Performance Computing for Engineering and Finance

**Professor:** Frédéric Magoulès

**Language of instruction:** English\* – **Number of hours:** 36 – **ECTS:** 3

**Prerequisites:** Basic knowledge in linear algebra (matrix, vector), numerical analysis (direct methods, iterative methods), and programming

**Period:** S8 Elective 09 February to March IN28IE2, SEP8IE2

#### Course Objectives

To provide an overview of the state of the art of high performance computing as applied to engineering and finance. Special references will be given to parallel and distributed computing and how serial or sequential algorithms problems may be parallelized for the efficient solution of large scale problems in computational engineering, financial engineering, analysis, simulation and design.

#### On completion of the course, students should be able to

- ✧ understand modern computer architecture
- ✧ have good knowledge of numerical methods well suited for parallel and distributed computing
- ✧ be familiar with parallel and distributed programming

#### Course Contents

- ✧ Architecture of scientific computer: type of parallelism, memory architecture.
- ✧ Parallelism and programming models: parallelization, performance criteria, data parallelism, vectorization, message passing.
- ✧ Parallel algorithm: recursive parallel algorithm, matrix-matrix product, spatial distribution
- ✧ Direct methods for large linear systems: LU factorization, Gauss algorithm, Gauss-Jordan algorithm, Crout and Cholesky factorization for symmetric matrices
- ✧ Parallel factorization of dense and sparse matrices: block factorization, implement of the block factorization in a message passing environment, symbolic factorization, renumbering, elimination tree, bisection methods.
- ✧ Iterative methods for large linear systems: Lanczos method, conjugate gradient method, GMRES method, ORTHODIR method, etc.
- ✧ Parallelization of Krylov's methods: parallelization of dense matrix-vector product, parallelisation of sparse matrix-vector product
- ✧ Brief introduction to C and C++ languages for the exercises

#### Course Organization

Lectures: 18 hr, Tutorials: 9 hr, Labwork: 9 hr

#### Teaching Material and Textbooks

PARALLEL SCIENTIFIC COMPUTING Author(s): Frederic Magoules, Francois-Xavier Roux, Guillaume Houzeaux Wiley-ISTE, London, UK. Hardcover: 372 pages 2015: ISBN-13: 978-1848215818

CALCULO CIENTIFICO PARALELO (IN SPANISH) Author(s): Frederic Magoules, Francois-Xavier Roux, Guillaume Houzeaux CIMNE, Barcelona. Paperback: 311 pages 2014: ISBN: 978-84-941686-3-5

HEIRETSU KEISAN-NO SUURI-TO ALGORITHM (IN JAPANESE) Author(s): Frederic Magoules, Francois-Xavier Roux, Takuya Kuwahara Morikita Publishing Co Ltd, Tokyo, Japan. Paperback: 256 pages 2015: ISBN-13: 978-4627807112

CALCUL SCIENTIFIQUE PARALLELE: COURS, EXEMPLES AVEC OPENMP ET MPI, EXERCICES CORRIGES (IN FRENCH) Author(s): Frederic Magoules, Francois-Xavier Roux Dunod, Paris, France. Collection Sciences Sup, Mathematiques Appliquees pour le Master / SMAI. Paperback: 286 pages 2013: ISBN: 978-2-10-058904-3

### **Evaluation**

Project with written report and oral defense + final written exam\_