Last update: 23-04-2019

220127 - Mathematics and Computing Engineering

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering

Teaching unit: 726 - MA II - Department of Applied Mathematics II

Academic year: 2019

Degree: BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2010). (Teaching unit Optional)
BACHELOR'S DEGREE IN TEXTILE TECHNOLOGY AND DESIGN ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN AUDIOVISUAL SYSTEMS ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Optional)

ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Rafel Amer

Teaching methodology

The course follows a project based learning methodology and introduces computational techniques arising in engineering. Projects include thecniques like numerical linear algebra, numerical integration of systems of ordinary differential equations, finite-element discretization of partial differential equations, eigenvalue problems and montecarlo simulations methods.
With regard to computing, computer programming, algorithms, and parallel computing play a major role in computational science and engineering. The most widely used programming language in the scientific community are Fortran, C and C++, while the proprietary language/environment Matlab is also widely used, especially for rapid application development and model verification. Pyhon along with external libraries such as Numpy, SciPy and Matplotlib has gained popularity as a free alternative to MATLAB.
In the Large group, the teacher will present the key concepts of the projects and will help the students to discover what they need to learn to develop a solution to the assignments proposed.

Learning objectives of the subject

A large number of packages exist that provide computational modelling capabilities. If these satisfy the research or design needs, and any data processing and visualisation is appropriately supported through existing tools, one can carry out computational modelling studies without any deeper programming knowledge.
In a research environment, both in academia and research on new products or ideas in industry, one often reaches a point where existing packages will not be able to perform a required simulation task, or where more can be learned from analysing existing data in news ways. At that point, programming skills are required. It is also generally useful to have a broad understanding of the building blocks of software and basic ideas of software engineering as we use more and more devices that are software-controlled.

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The course introduces the students basic programming concepts and the use of packages like FFTW (Fastest Fourier Transform in the West), GSL (GNU Scientific Library), GMP (GNU Multiprecision Library), SuitSparse, ScyPy, NumPy, Matplotlib, OpenMPI (Message Passing Interface), POSIX Threads, PETSc (Portable Extensible Toolkit for Scientific Computation), etc. to develop programs related to computational mathematics, physics and engineering.

Study load

Total learning time: 75h	Hours large group:	30h	40.00%
	Self study:	45h	60.00%

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Content

Module I. Numbers, numbers, numbers

Learning time: 15h
Theory classes: 6h
Self study : 9h

Description:
1. Read from a file and compute the product of two very large integers, say 200.000 digits each.
2. How compute the product efficiently?
3. Compute 2.000 decimal digits of the numbers e and pi.
4. Maybe we can compute one billion decimal digits of e and pi with a standard PC.

Module II. Linear algebra

Learning time: 15h
Theory classes: 6h
Self study : 9h

Description:
1. Solve a system ot thousand linear equations with thousand unknowns.
2. What if the the system has one million equations and one million unknowns?
3. Google Pagerank. PageRank is an algorithm used by Google Search to rank websites in their search engine.
4. Eigenfaces reconigtion. Eigenfaces is the name given to a set of eigenvectors when they are used in the computer vision problem of human face recognition.
5. Wavelets and image compression.

Module III. Integration and differential equations

Learning time: 15h
Theory classes: 6h
Self study : 9h

Description:
1. Numerical integration.
2. Motion of a pendulum, a chaotic pendulum or a double pendulum.
3. Springs and masses.
4. The Lotka-Volterra predator-prey equations.

Module IV. Partial differential equations

Learning time: 15h
Theory classes: 6h
Self study : 9h

Description:
1. Solve a one dimensional boundary value problem programming the finite element method.
2. Solve partial differential equations with FeniCS.
3. Financial engineering with finite elements.
4. Parallel implementation of finite element code using PETSc.

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Module V. Monte Carlo methods	Learning time: 15h Theory classes: 6h Self study : 9h

Description:
1. Numerical integration.
2. Random walks and brownian motion.
3. Monte Carlo methods in financial engineering.
4. Monte Carlo optimization

Regulations for carrying out activities

Projects are done by teams of students, generally two or three persons per team. Projects to be developed by each team will depend on the number of his members, with a minimum of three projects.

Each team must provide a write-up for each part of the projects. This must describe the group?s efforts to address each step in the assignments. Each student

The final grade depends on the following assessment criteria:
- ritten documentation and/or oral presentation (25%)
- Computer programs for the projects (60%).
- Participation in Large group (15%).

Bibliography

Basic:

Schäfer, Michael. Computational Engineering. Introduction to Numerical Methods [on line]. Berlin, Heidelberg: Springer Berlin Heidelberg, 2006Available on: <http://dx.doi.org/10.1007/3-540-30686-2>. ISBN 9783540306863.