Mathematics - Computer Science - Economics

ECTS credits
4 credits

Semester
Fall

In brief

Course langage: French

Presentation

Prerequisites

- Programs of the course units Mathematics 1A, Computer Science 1A and Economics-Business 1A from Ecole Centrale Méditerranée Engineering programme (see syllabus 1A)
- Basics of the Python language

Learning objectives

- Apply a field of applied mathematics (Probability-Statistics, Finite Elements, Optimal Transport) to applications
- Design a computer program by implementing the necessary steps with the adequate tools: modeling, algorithms, programming environment in Python
- Understand advanced economic concepts related to strategic behavior and information asymmetries, particularly as they apply to financial intermediation and macroeconomic policies

Description of the programme

The major course unit Mathematics-Computer Science-Economics (MIE) is divided into 3 periods, each period is equal to 4 weeks (18h et 6h d'autonomie). For each period, the student must choose one subcourse offered in one of the following fields: Mathematics, Computer Science or Economics. There is one constraint for the student's choices (except for international credit mobility students such as Erasmus+ students): at the end of the semester the student must have studied subcourses in at least two different fields among Mathematics, Computer Science and Economics.

Choice of a course among Mathematics, Computer Science or Economics at each period

Mathematics - Computer Science - Economics

	Period 1 (Temps 1)	Period 2 (Temps 2)	Period 3 (Temps 3)
Mathematics	Probability & statistics	Variational methods for PDEs and finite elements	Introduction to the theory of optimal transport
Computer Science	Coding and developing in Python	Optimization algorithms	Scientific Python
Economics	Applied macroeconomics	Economics of bankink: banks role and related risks	Business strategy: competition and the market

Mathématiques

1. M1 : Probability and statistics
    1. Conditional probability and conditional expectation: definition, conditional probability distribution, properties, Bayes formula, martingales
    2. Inferential statistics: parametric estimation (maximum likelihood, moment method, regular model and Fisher information, confidence interval, parametric tests (likelihood ratio test) and nonparametric tests (chi-square)
2. M2 : Variational methods for PDEs and finite elements
    1. Distributions : definition, convergence, derivative
    2. Hilbert space, Sobolev spaces, inequalities (Cauchy-Schwarz, Minkowski), Green formula, semi-norm
    3. Variational methods: Lax-Milgram theorem, Galerkin methode (definition, convergence and order).
    4. Finite elements: definition, approximation space, convergences for the local approximation and for the global approximation, convergence theorem for the Lagrange finite-element method
3. M3 : Introduction to the theory of optimal transport
    1. Monge and Kantorovitch formulations,
    2. Kantorovitch duality, c-concave functions, applications in economics: matching equilibrium
    3. Wasserstein distance, generalized Wassertsein distance (unbalanced optimal transport)
    4. Computational methods: Sinkhorn algorithm, entropic regularization, Benamou-Brenier formulation

Computer Science

1. I1 : Coding and developing in Python
    1. IT project development methods: code management, test-driven development
    2. Advanced object-oriented programming (Python)
2. I2 : Optimization algorithms
    1. Linear programming and continuous methods for Operational Research
    2. Multi-criteria optimization
    3. Combinatorial optimization and approximate solution methods (Monte Carlo, simulated annealing, genetic algorithms, etc.)
3. I3 : Scientific Python
    1. Data manipulation and data analysis with Python: libraries Numpy and Scipy
    2. Graphs in Python: library Matplotlib
    3. Dataframe manipulation and representation: libraries Pandas and Seaborn
    4. Image processing: library Scikit-image

Economics

1. E1 : Applied macroeconomics
   1. Growth, Inflation and Unemployment
   2. Economic Fluctuations
   3. Modeling of Economic Fluctuations
   4. Budgetary Policy and Public Debt Dynamics
   5. Monetary Policy
2. E2 : Economics of banking: banks role and related risks
   1. Role of banks in the economy
   2. Financial intermediation in the face of information asymmetries
   3. Bank and banking system fragility
   4. Bank regulation: capital, sustainability and central banks
3. E3 : Business strategy: competition and the market
   1. Market Ssructures: monopoly, duopoly, and oligopoly
   2. Competition: price vs. quantity
   3. Price discrimination and the development of effective business strategies to cope with the competition
   4. Firm behavior when facing non-fully rational or boundedly rational customers

Generic central skills and knowledge targeted in the discipline

- M1: Model a statistical experiment for an i.i.d. sample and implement standard pointwise and interval estimation methods as well as testing procedures
- M2: Write and analyze a week formulation for a PDE. Implementation in Finite Element software.
- M3: Formulate the optimal transport problem and calculate Wasserstein distances
- I1: Develop and maintain computer code
- I2: Understand the main classes of optimization algorithms and how to implement them
- I3: Program in Python with the Numpy, Scipy, Matplotlib, Pandas, Seaborn and Scikit-image libraries
- E1: Understand the goals and implementation of public policies (budgetary and monetary).
- E2: Identify and describe the role of banks and the banking system in the economy, as well as the reasons leading to its fragility and its regulation.
- E3 : Be able to analyze business strategies and consumer behavior in various market contexts, while developing analytical, critical, and ethical skills.

How knowledge is tested

Continuous assessment: Each course is assessed, at the discretion of the course instructor, through a combination of written exams, projects, homework assignments, and other assignments. The assessment schedule is completed by the teaching team at the beginning of the year and submitted to the engineering program administration for publication to the students.

In Session 1, the final grade is the average of the grades earned in the three courses taken (one course per Term).

If a student takes a course in two or more sessions, the final grade is the average of the grades earned in the three sessions, applying the standard rule that allows a student to retain a grade from a previous session for a course if it is higher than the grade earned in the most recent session (see academic regulations).

Bibliography

A bibliography will be proposed at the beginning of each subcourse offered in the major course unit Mathematics-Computer Science-Economics.

Teaching team

1. **Mathematics**
   1. M1 : Christophe Pouet, Ary Ramarolahy, Frédéric Schwander
   2. M2 : Marie Billaud-Friess
   3. M3 : Magali Tournus
2. **Computer Science**
   1. I1 : François Brucker
   2. I2 : Emmanuel Daucé, Pascal Préa
   3. I3 : Muriel Roche
3. **Economics**
   1. E1 : Mohamed Belhaj
   2. E2 : Renaud Bourlès
   3. E3 : Jiakun Zheng and teaching assistant

Sustainable Development Goal

Climate action

Peace, justice and strong institutions

Reduced inequalities

Responsible consumption and production

Sustainable cities and communities

Total des heures		**72h**
CM	Master class	54h
AA		18h

Useful info

Name responsible for EU

Lead Instructor

Christophe Pouet

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