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 concepts in economics about markets or strategic behavior or process data related to an economics problem.

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 and finite elements	Introduction to the theory of optimal transport
Computer Science	Algorithm design	Data driven programming	Scientific Python
Economics	Applied macroeconomics	Strategic behaviours: game theory	Economics of banking: banks role and related risks

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 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 Kantorovitc 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 : Algorithm design
    1. Algorithm divide & conquer
    2. *Sequence alignment* problem: sequence alignement problem, sequence alignement algorithm
    3. Dynamic programming and NP-completeness
    4. Greedy algorithms: principles and implementation
    5. Enumeration problem: branch-and-bound strategy and backtracking strategy
2. I2 : Data driven programming
    1. Event-driven programming and persistent objects. Python object. CRUD principle. MVC design template.
    2. Persistence managers: ORM, DAO. web servers. HTML/CSS. Django, pony ORM, Django ORM.
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 : Strategic behaviours: game theory
   1. Dominated strategy and Iterated elimination of strictly dominated strategies (IESDS)
   2. Nash equilibrium: definition, best answers, connection between IESDS-Nash
   3. Mixed strategy: definition, investigation of mixed equilibrium, Nash theorem, interpretation of mixed Nash equilibrium
   4. Games with continuous action space
   5. Sequential games
3. E3 : 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

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: Understand the main categories of algorithms and how to implement them
- I2: Implement event-driven programming in Python and understand the notion of persistence
- 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: Analyze strategic interactions between rational actors to predict their decisions.
- E3: 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.

How knowledge is tested

Continuous assessment

Bibliography

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

Centrale Méditerranée

Mathematics - Computer Science - Economics

Teaching team

1. **Mathematics**
   1. M1 : Christophe Pouet, Mitra Fouladirad, Frédéric Schwander
   2. M2 : Guillaume Chiavassa
   3. M3 : Magali Tournus
2. **Computer Science**
   1. I1 : Pascal Préa, Emmanuel Daucé
   2. I2 : Emmanuel Daucé, Catherine Jazzar
   3. I3 : Muriel Roche, temporary instructors
3. **Economics**
   1. E1 : Mohamed Belhaj
   2. E2 : Sebastian Bervoets (AMU-CNRS)
   3. E3 : Mohamed Belhaj, Renaud Bourlès

Sustainable Development Goal

Climate action

Peace, justice and strong institutions

Reduced inequalities

Responsible consumption and production

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

Useful info

Name responsible for EU

Lead Instructor

Christophe Pouet

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