

RealMaths
International Double MSc Degree Programme in Mathematics for
Real World Applications

The list of subjects and topics:

Algebraic methods in cryptography

- Discuss the difference between symmetric and asymmetric ciphers. Give an example of any symmetric and asymmetric cipher.
- How to check if a number is prime? Give several methods and demonstrate them using the example of any odd three-digit number.
- Discuss the principles of modular arithmetic.

Computability

- Turing computable functions. Church-Turing Thesis.
- Unsolvable problems. Give an example of an unsolvable problem.
- Recursive functions. Computable functions.

Dynamical systems on measures: financial, physical and biological models

- **The gamma distribution:** basic properties and applications
- **Metrics and norms in the space of measures:** Fortet–Mourier metric, Kantorovich–Wasserstein metric, total variation metric. The relationships between metrics. The Kantorovich-Rubinstein maximum principle.
- **Kantorovich-Rubinstein duality theorem.** The transport of mass problem. The space of admissible transference plan. The unit cost of shipment and the total cost. The relationship between minimization of transportation costs and the Kantorovich-Rubinstein maximum principle.
- **Markov operators - properties and applications:** Markov operator and dual operator. The relationship between Markov and dual operator. Basic properties. Discrete time stochastically perturbed dynamical system. Iterated function system
- **Invariant principle:** Semidynamical system. Limiting point of a trajectory. Properties of an invariant sets. Lyapunov-LaSalle function - properties. Invariant Principle.
- **Lasota's theorem – Lower bounded technique.** Asymptotically stable of Markov operator. Lower-bound function - properties. Lasota's theorem. Markov operators defined by a stochastic kernel. The linear Tjon - Wu equation. Collision operator - probabilistic and physical interpretation.
- **Poisson driven stochastic differential equation.** Poisson process. Definition and properties of the solution of the Poisson driven stochastic differential equation. Stochastic model of the cell cycle.

Mathematical modelling in engineering and economics

- Discuss some method of selecting the variables to the mathematical model and some method of estimating the parameter values of such model.
- Discuss selected methods of assessing the quality of the estimated mathematical model.
- Discuss the issue of predicting by using an estimated mathematical model.

Numerical methods in technics

- The difference between approximation and interpolation? Discuss selected approximation method and selected interpolation method.
- Discuss selected method of numerical integration.
- Discuss selected method of numerical solution of the problems expressed by means of differential equations.

Stochastic models

- Poisson process, its main properties and applications.
- Discrete-time Markov chain, its main properties and applications.
- Birth-death stochastic process, its main properties and applications.

Computing software systems

- Discuss the differences between symbolic and numerical calculations. Illustrate the differences with some example.
- Discuss any algorithm for determining the roots of a function.
- Discuss the rectangle rule (the Riemann sum method).