UCLouvain

lsinc1113

2023

Additional Mathematics

5.00 credits	30.0 h + 30.0 h	Q1

This learning unit is not open to incoming exchange students!

Teacher(s)	Gousenbourger Pierre-Yves ;
Language :	French
Place of the course	Charleroi
Prerequisites	This course assumes acquired notions of analysis (LSINC1111 or LINFO1111) and algebra (LSINC1112 or LINFO1112) acquired in the first year of the bachelor's degree. *The prerequisite(s) for this Teaching Unit (Unité d'enseignement – UE) for the programmes/courses that offer this Teaching Unit are specified at the end of this sheet.*
Main themes	**Complex numbers** Complex numbers Complex exponential Fourier transforms Filtering Sampling - Nyquist **Two-variable functions** notion and calculation of partial derivative graphical interpretation of the gradient interpretation and calculation of the hessian matrix Intuitive introduction to using the gradient and the Hessian matrix for a 2-variable function to determine critical points and their nature notion and calculation of double integrals **Introduction to number theory** Natural integers, principle of recurrence, prime numbers, etc. Equivalence, equivalence classes Euclidean division, representation in a base, modulo arithmetic, representation of integers in the computer Pcgd, Euclid's algorithm Fundamentals of cryptography **Introduction to graph theory** Directed and undirected graphs and their matrix representations Bipartite graphs and matching problems Paths on a graph and Eulerian/Hamiltonian circuits Planar graphs and coloring Shortest path problems Ranking of graph nodes: PageRank
Learning outcomes	**At the end of this learning unit, the student is able to :** With regard to the AA reference system of the "Bachelor in Computer Science" program, this course contributes to the development, acquisition and evaluation of the following learning outcomes: • S1.I1, S1.G1 • S2.2 **Students who successfully complete this course will be able to:** • S1.I1, S1.G1: Manipulate complex numbers and understand their concrete applications • S2.2: Apply their knowledge of analysis to functions of two variables Use the properties of numbers in simple cryptography problems Model various real-world problems encountered in computer science using appropriate forms of graphs Explain the shortest path problem in a graph and apply classical algorithms to solve this problem
Evaluation methods	The student's learnings will be evaluated and rated based on an oral interview.

Teaching methods	The course is a face-to-face course organized in a hybrid way between a frontal course and a discussion with the students. Drill exercise sessions are organized to master the concepts and laboratory sessions (with computer) are planned to better understand the computer aspect of the themes.
Content	The LSINC1113 course (Mathematics Complements) complements those of Analysis (LSINC1111) and Algebra (LSINC1112) and offers you the opportunity to discover four more advanced themes. **Multivariate analysis** is the continuation of the analysis course seen in the first year. The concepts are extended to multivariate functions that are more representative of what is encountered in nature. One of the main advantages of this part of the analysis is to be able to optimize complex processes. **Signal processing** is well known in health sciences (and technologies in general), since it is a branch of mathematics used to denoise images, filter sounds, transmit them by radio, or yet to interpret electrocardiograms to, for example, trigger an alarm. This part is based on a very powerful mathematical concept called the Fourier transform. **Number theory** is a very special field. All numbers must be integers. Yet this theory supports modern cryptography, necessary for banking transactions, communications between machines, and data encryption! Finally, **graph theory** makes it possible to represent, study and understand networks of interconnected objects, people or neurons. ***The objective of this course is to allow students to discover applications related to the world of health where advanced mathematics is essential. An introductory understanding of these mathematical concepts is necessary to be able to develop computer solutions related to these applications.*** The learning outcomes related to these different themes are described below. **Multivariate analysis** At the end of this part, the student will be able to: • Perform simple operations involving multivariate functions; • Explain the concept of partial derivative and calculate simple partial derivatives on bivariate functions; • Explain the concept of gradient of a function, calculate a simple gradient, and interpret it graphically; • Explain the concept of hessian of a function, calculate a simple hessian; • Use the gradient and the hessian to determine the critical points (and their nature) of a simple bivariate function by explaining the role that each of these objects play; • Determine the value of a simple double integral; • List different applications in daily life and in the health sciences where multivariate functions can be observed. **Signal processing** At the end of this part, the student will be able to: • Perform simple operations (add, subtract, multiply, divide and raise to a power) involving complex numbers in their different forms (Cartesian, polar and exponential) and solve basic equations; • Understand and explain the concept of Fourier transform in the context of signal processing and calculate simple Fourier transforms according to the definition or via properties; • Define and explain the concept of spectrum of a signal; • Explain the concept of filters (high-pass, low-pass, band-pass), represent it, and shape simple filters; • Check and explain the sampling conditions via the Shannon-Nyquist theorem; • Explain the spectral fallback phenomenon. • Name different applications in everyday life and in the health sciences where signal processing plays an important role. **Introduction to number theory** • At the end of this part, the student will be able to: • Use the principle of recursion in simple demonstrations and in exercises involving natural numbers; • Explain the basic concept of number encoding and how they are represented in a computer; • Perform a simple Euclidean division between two natural numbers to extract the quotient and the remainder from it; • Perform simple operations using modulo arithmetic; • Define and verify that a number is prime using simple algorithms; • Define the notion of equivalence and equivalence class (modulo p), and verify that two numbers are equivalent (modulo p) or belong to the same equivalence class; • Define and explain the notion of discrete logarithm; • Understand and explain the basic concepts of cryptography (public key, private key, precautionary principle, Alice, Bob, Eve, data encryption, etc.); • Explain the Diffie-Hellman cryprographic algorithm. • Name different applications in everyday life and in the health sciences where cryptography plays an important role. **Introduction to graph theory** At the end of this part, the student will be able to: • Define and represent the basic concepts of graph theory (node, edge, simple graph, directed graph) using the appropriate vocabulary and rigorous notations; • Represent a graph in matrix form (incidence and adjascence matrix); • Finally, represent and verify that a graph is bipartite, and explain how this concept makes it possible to solve matching problems;

	• Define and explain the notions of circuits and paths (Eulerian and Hamiltonian) on a graph and be able to check if a graph is indeed Eulerian; • Explain and apply simple graph theory algorithms (coloring, shortest path, page rank); • Name different applications in everyday life and in the health sciences where graphs play an important role.
Inline resources	Ressources and announcements are placed on Moodle.
Faculty or entity in charge	SINC

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Bachelor in Computer Science	SINC1BA	5	LSINC1111	🔍