INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

2nd YEAR FAS NUMERICAL

Introducing

Description

Évaluation

L'évaluation des acquis d'apprentissage est réalisée en continu tout le long du semestre. En fonction des enseignements, elle peut prendre différentes formes : examen écrit, oral, compte-rendu, rapport écrit, évaluation par les pairs...

Practical info

Location(s)

Toulouse

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Analysis 1

Introducing

Description

Integration

Improper integrals: integrals of positive functions, functions of any sign, absolute convergence and semi-convergence

Parameter-dependent integrals: dominated convergence theorem, continuity, differentiability

Multiple integrals: Fubini's theorem, change of variable theorem

Numerical Series

Introduction, partial sums and summation techniques

Series with positive terms, comparison theorem

Series with arbitrary terms: absolute convergence, alternating series test

List of Competencies:
1_1: Master the mathematical concepts and computational tools of the engineer
1_2: Establish rigorous scientific reasoning and develop the capacity for abstraction
2_1: Master the fundamental tools of the mathematical engineer

Objectives

The student shall be able to:

Study the differentiability of a function of several variables and perform a limited (Taylor) expansion

Perform integral calculations of functions of several variables or over unbounded domains

Search for extrema of a function of class C1C1 or C2C2

Study the convergence of a numerical series using bounding and comparison methods

The student shall have understood and be able to explain (main concepts):

The notion of the differential of a function of several variables, partial derivatives, and their relation to the differential

The notion of improper integrals, integrals of parameter-dependent functions or of functions of several variables

The notion of numerical series and the concept of convergence of numerical series

Necessary prerequisites

First-year Linear Algebra: Vector spaces, linear maps, matrices, concept of image and kernel of a linear map.
First-year Analysis Course: Functions, limits, continuity, differentiability in one dimension, linear algebra (vector spaces, linear maps, matrices, vectors).

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Practical info

Location(s)

Toulouse

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Algebra

Introducing

Description

Solving Linear Systems

Gaussian elimination, row and column operations, matrix interpretation

Pre-Hilbert and Euclidean Spaces

Scalar product: examples and properties

Orthogonality: Pythagoras' theorem, orthogonal bases, orthogonal projection

Reduction of Endomorphisms

Eigen-elements: eigenvalues, eigenvectors, characteristic polynomial

Diagonalization, triangularization

Applications: differential systems and linear recurrences

Endomorphisms of Euclidean Spaces

Isometries, orthogonal matrices

Reduction

Bilinear Algebra

Symmetric positive definite matrices: definition, properties, characterization

Orthogonality

List of Competencies:

1_1: Master the mathematical concepts and computational tools of the engineer

1_2: Develop rigorous scientific reasoning and the capacity for abstraction

2_1: Master the fundamental tools of the mathematical engineer

Objectives

The student should be able to:

Solve linear systems using row and column operations and provide a matrix-based interpretation.

Compute an orthogonal basis and perform orthogonal projections.

Provide a matrix interpretation of the main classes of endomorphisms in Euclidean spaces.

Diagonalize and triangularize simple matrices.

The student should have understood and be able to explain (main concepts):

The main results concerning matrix reduction.

The concept of scalar product and orthogonality.

The notion of Euclidean space and isometry.

Necessary prerequisites

First-year Linear Algebra: Vector spaces, linear maps, matrices, the concepts of image and kernel of a linear transformation.

First-year Analysis: Functions, limits, continuity, differentiability in one dimension, linear algebra (vector spaces, linear maps, matrices, vectors).

Évaluation

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Practical info

Location(s)

Toulouse

Continuous automatics

Introducing

Description

This course deals with the modeling, analysis and control of continuous linear systems. It presents the classical methods of frequency automata. They are based on the transfer function representation, obtained from the Laplace transform. The stability property and their temporal and frequency responses, in the form of Bode and Nyquist diagrams, are studied. We analyze the performance of a servo system, in terms of accuracy, transient regime and stability margins. Finally, the synthesis of correctors is approached by studying the effects of elementary corrections, before combining them to set PI, PID and phase lead controller.

Objectives

At the end of this module, the student should have understood and be able to explain the main concepts of the automatic control of continuous linear systems:
- model a continuous linear system in the form of transfer functions and block diagrams
- calculate the time and frequency responses of a continuous linear system, and analyze its stability
- analyze the main properties of a servo system (stability, transient regime, accuracy and stability margins)
- synthesize, using the classical frequency method, some controller (elementary corrections, PI, PID, phase lead)

Évaluation

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Practical info

Location(s)

Toulouse

Discrete automatics

Introducing

Description

The second part covers discrete event systems control. It includes the general structure of a sequential system and the study of elementary sequential functions (flip-flops, counters). It also addresses the synthesis and analysis of a sequential logic system. The Huffman method is introduced, as well as simplified sequencer synthesis. The realization will be done using flip-flops for synchronous systems. Additional information is provided on Huffman synthesis for asynchronous sequential logic systems (issues of hazards and races). The formalism of Petri nets is introduced for specifying problems related to parallelism, synchronization, and critical resource management, as well as the statecharts formalism.

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):
• Sequential logic: synthesis and analysis
The student should be capable of:
• Conducting minimal synthesis and analysis of a sequential system based on flip-flops, including that of a sequencer (synchronous systems).
• Analyzing and synthesizing complex asynchronous sequential logic systems, identifying and resolving issues related to static hazards and races.
• Modeling a system with parallelism, synchronization, and shared resources using the formalism of Petri nets or statecharts, and analyzing properties (safe, live, and sound) of a network through the marking graph.

Necessary prerequisites

Combinatory logic

Évaluation

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Practical info

Location(s)

Toulouse

Electrostatics (Elective course)

Introducing

Description

Mathematics needed to solve problems
Electric charge and distribution of electric charges
Electric field
Electric potential
Gauss's theorem

Objectives

Acquisition of the basics of electrostatics.
Learning formalism, implementation of scientific reasoning and calculation methods.

Évaluation

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Practical info

Location(s)

Toulouse

Algorithmics and Programming 1

Introducing

Description

Formal study of algorithms (expression, correction, complexity).
Recursion.
Good programming practices.
Memory management.
ADA and Python programming languages.

Objectives

Learn to decompose the development of a program, from the expression of an algorithm on paper to its implementation in different languages.

Necessary prerequisites

First-year algorithmic course at INSA :
- basics of imperative algorithmics: variable, instruction, conditional branching, loop, sub-algorithm,
- ADA programming: syntax, typing.

Évaluation

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Practical info

Location(s)

Toulouse

Unix

Introducing

Description

The command interpreter (the shell), variables, iterative structures, control structures,
Programming using the command language (essentially bash),
Handling the file system and, in particular, access rights,
User management (uid, gid, home directory, etc),
I/O and pipe redirection mechanisms.
Some general information on documentation, archiving, compression and a few network commands.

Objectives

At the end of this module, the student will be able to use the command interface of the Unix operating system independently.

Necessary prerequisites

No required

Évaluation

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INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Combinatorial logic

Introducing

Description

Évaluation

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Electronic systems for communication

Introducing

Description

The objective of this course is to introduce the fundamentals of analog and digital electronic systems used by engineers designing electronic communications systems. Organized into thirteen sections, the course aims to cover the analog and digital functions typical of a telecommunications system, such as that of a cell phone. The signal conditioning aspect is addressed by presenting various analog filter structures, with the canonical expressions demonstrated. Operational amplifiers (Op Amps) are studied in linear mode in Laplace space, followed by their study in saturated mode.

The second part of the course covers the concepts of digital electronics: combinational and sequential logic, gates, flip-flops, registers, multiplexers, converters, and memories. The connection to digital signal processing is introduced through CAN and DAC architectures. The issue of communication and interfacing between different logic families is analyzed, associating communication protocols with transmission modes (synchronous, asynchronous, duplex, etc.).

Objectives

At the end of this module, the student should have understood and be able to explain the following main concepts:
- Basic concepts of signal processing (amplification, filtering, Fourier transform)
- Operation of an ideal amplifier and limitations of a real operational amplifier
- Basic Op Amp-based analog electronics setups
- Linear and saturated operating conditions of an Op Amp-based circuit
- The difference between analog and digital electronics
- Basic principles of analog-to-digital conversion (sampling, quantization, Shannon's theorem)
- Physical characteristics of digital circuits
- Gate and flip-flop architectures of simple digital circuits (counter, register, multiplexer)
- Basic principles of digital signal transmission
- Basic principles of analog and digital modulation

The student should be able to:
- Calculate the Laplace transform of the transfer function of an analog circuit
- Design a first-order filter
- Design a simple Op Amp-based analog function (amplifier, integrator, summing circuit)
- Set up an analog-to-digital conversion chain
- Wire analog and digital circuits

Necessary prerequisites

General laws of electricity.
Signal processing basics (Fourier transform, frequency domain representation).
Logic systems.

Évaluation

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Practical info

Location(s)

Toulouse

Expression

Introducing

Description

Évaluation

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Practical info

Location(s)

Toulouse

Contemporary economy and ecological transition

Introducing

Description

The main areas studied are as follows:

- The market
- Economic actors
- Income and distribution
- Economic growth
- Unemployment
- Financing the economy
- Currency and inflation
- Economic policies
- New economic models

Objectives

The objective of this course is to provide basic concepts allowing students to better understand their current and future environment and to identify the main issues.

Students will be able to carry on a conversation and debate using arguments based on knowledge of fundamental economic mechanisms and some theories of economic thought.

Necessary prerequisites

None

Évaluation

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Practical info

Location(s)

Toulouse

Foreign Language 1

Introducing

Description

Évaluation

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Practical info

Location(s)

Toulouse

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Internship defense

Introducing

Description

Évaluation

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Practical info

Location(s)

Toulouse

Professional path initiative

Introducing

Description

Évaluation

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Practical info

Location(s)

Toulouse

Physical Activities and Sports

Introducing

Description

The APS (Physical and Sports Activities) offering is structured around several categories:

Team sports: football, basketball, volleyball

Individual sports: tennis, badminton, climbing, judo, strength training, gymnastics

Artistic and expressive activities: circuit training, dance

Outdoor activities: outdoor physical and nature-based activities (OPNA), golf

Adapted sports: adapted strength training, learn-to-swim, learn-to-ride, Pilates, sophrology

At the beginning of the academic year, students use a dedicated platform ("choix APS") to rank the available APS options in order of preference. Each student is then assigned an activity based on their choices and availability.

All APS sessions are supervised by certified PE teachers, either permanent staff (CAPEPS, AGREGATION holders) or external instructors.

Objectives

At the end of this module, the student should have understood and be able to explain the following key concepts:

Deepened self-awareness.

Ability to interact effectively with others.

The student should be able to:

Analyze a problem collaboratively (identify the issue, define possible approaches through interactive discussion).

Facilitate group expression and decision-making, allowing everyone to share their opinion.

Adjust and regulate their behavior in response to others.

Identify their own strengths and weaknesses, as well as those of others.

Apply these insights in the context of physical and sports practice.

Évaluation

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Practical info

Location(s)

Toulouse

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Signal 1

Introducing

Description

Program (detailed contents):
- Hilbert Spaces : scalar products, projection onto a vector subspace, approximation of a vector in a basis.
- Fourier series : definition, properties, Parseval's theorem and Dirichlet's theorem. Gibbs phenomenon.

Objectives

At the end of this course, the student will have understood and be able to explain (main concepts):
- Fourier coefficients, partial sums and Fourier series of piece-wise continuous functions.
- Various notions of convergence of Fourier Series.

The student will be able to:
- Compute the Fourier coefficients of a function.
- Compute some series and solve equations using Fourier coefficients.

Necessary prerequisites

Integrals, complex numbers, series.

Évaluation

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Practical info

Location(s)

Toulouse

Energy Mix and Transition

Introducing

Description

The main concepts covered during the course are: conversion, transport, storage and usage efficiencies / power flux density / material resource intensity / load factor / stock and flow concepts / production and demand profiles / networking / energy mix / energy transition scenarios for 2050.
The course covers the following technologies: wind generation, electrolytic storage (H2), photovoltaics, electrochemical batteries, hydroelectricity / WWTP, fossil-nuclear-biomass power stations, biogas production.

Objectives

To understand the stakes involved in supplying energy to our production system.
To be able to answer the following questions:
- How do we obtain our energy today (knowing the different means of conversion and storage, and the different mixes) ?
- What are the orders of magnitude for our individual and national energy consumption on a day-to-day basis ?
- Where are the dependencies, weaknesses and limits of our energy supply ?
- How can we build an energy mix that meets our demand profile up to 2050 and the challenge of decarbonization ?

Necessary prerequisites

Be familiar with the concepts of electrical power and energy, as well as the general concepts of efficiency and density.
Have acquired the knowledge and skills of the first year at INSA, especially in electrokinetics, mechanics and thermodynamics.

Évaluation

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Practical info

Location(s)

Toulouse

Analysis 2

Introducing

Description

Sequences of Functions

Pointwise convergence, uniform convergence

Properties of limits of functions

Series of Functions

Pointwise, uniform, and normal convergence

Properties of series of functions

Case of power series

Linear Ordinary Differential Equations (ODEs)

Examples, general framework of affine ODEs

Particular case of linear ODEs with constant coefficients

Objectives

The student should be able to:

Study the pointwise and uniform convergence of a sequence and a series of functions

Analyze functions defined as sums

Solve linear differential equations with or without a forcing term

Solve linear systems of differential equations with or without a forcing term

Necessary prerequisites

First-year linear algebra: vector spaces, linear maps, matrices, the concepts of image and kernel of a linear transformation.
Manipulation of sets, calculations of sums and numerical series, derivatives, integrals (single and multiple), improper integrals, equivalent expressions, and limits.

Évaluation

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Practical info

Location(s)

Toulouse

Probability and statistics 1

ECTS

Hourly volume
26h

Introducing

Description

Program (detailed contents):

- Probability spaces

- Conditional probability and independence

- Random variables (discrete or continuous) and their characteristics

- Multidimensional random variables, conditional distributions and independence

- Limit theorems (LLN and CLT) and approximation of laws

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- what a probability space is

- the notion of conditional probability and independence between events

- what a random variable (discrete or continuous) and its characteristics are

- how to apply limit theorems such as the Law of Large Numbers (LLN) or the Central Limit Theorem (CLT)

The student will be able to:

- to compute probabilities using Bayes formula

- to determine the law of a random variable, to compute its expectation, variance, cumulative distributive and characteristic functions, etc

- to study the independence of random variables

- to approximate distributions by using underlying limit theorems

Necessary prerequisites

Basic set theory, summations and series, derivation, integration (both simple and multiple), improper integrals, equivalents and limit computations.

Évaluation

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Practical info

Location(s)

Toulouse

Algorithm and programming 2

Introducing

Description

Abstract types and implementation.
Linear data structures: stacks, queues, linked lists.
Tree-like data structures: binary trees, binary heaps, n-ary trees.
Hash tables.

Objectives

Learn to implement and use classic linear and tree data structures.

Necessary prerequisites

Algorithms and Programming I (previous semester).

Évaluation

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Practical info

Location(s)

Toulouse

Hardware architecture

Introducing

Description

- Functional description of the processor, its memory and caches, and associated technologies.
- Hardware-level functional description of paging and memory virtualization.

Objectives

At the end of this module, students will be able to describe how a computer works, based on its internal structural elements, and define the actions required at hardware level to perform a given task.

Necessary prerequisites

Basic notions of algorithmics and logic.

Évaluation

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Practical info

Location(s)

Toulouse

Language (C)

Introducing

Description

The conventional aspects (variables, types, control structures, iterative structures) are presented as well as the more specific points of the language (bit-by-bit operators, generalised use of pointers, parameter passing, input/output, etc.).

Objectives

At the end of this module, the student should have understood and be able to explain the programming of a particularly widespread computer language (C), including in particular the hardware-related aspects.

Necessary prerequisites

Notions of assembler and programming in an advanced language are welcome, as well as a minimum knowledge of computer architecture.

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Practical info

Location(s)

Toulouse

Digital culture and skills 1

Introducing

Description

Introductory course to AI: history, algorithms, issues.
"No code" discovery of neural networks on Vittascience; notebook for building a small character recognition network.
Presentation of PIX and study of a certain number of themes independently with the objective of passing the PIX certification at the end of the 3rd year.

Objectives

At the end of this module, the student will have discovered the first dimensions of the field of AI: history, examples of what AI allows, distinction between supervised and unsupervised learning, rapid scope of techniques and algorithms, ethical aspects, risks and controversies. In a second part, the student will have advanced his PIX course according to the defined program.

Necessary prerequisites

Basics of Python Programming

Évaluation

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Practical info

Location(s)

Toulouse

Mathematics tools (elective course)

Introducing

Description

Detailed Programme:
Topology
1. Sequences in a normed vector space (NVS)
2. Topology: open and closed sets, closure, density
3. Limits, continuity of functions, compactness (Bolzano) and Heine theorems
4. Linear maps between NVS: continuity, operator norms
Numerical Analysis
1. Concept of numerical error, floating-point number representation
2. LU and Cholesky factorization, matrix conditioning
3. Singular Value Decomposition (SVD)
4. Least squares solutions to Ax=bAx = bAx=b, QR factorization
5. Power method
6. Newton's method for solving F(X)=0F(X) = 0F(X)=0
7. Fixed-point method (lab work)
8. Numerical integration
9. Gradient method
Probability and Statistics
• Multidimensional random variables, conditional distributions, and independence

Objectives

List of Competencies:
• 1_1: Master mathematical concepts and computational tools relevant to engineering.
• 1_2: Develop rigorous scientific reasoning and abstraction skills.
• 2_1: Master the fundamental tools of the mathematical engineer.
(Based on the CTI Competency Framework, 2019)

Necessary prerequisites

• Working with sets, computing sums and numerical series, derivatives, integrals (single and multiple), improper integrals, equivalent expressions, and limits
• Programming in Python

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Location(s)

Toulouse

Physics 2 (elective course)

Introducing

Description

Materials: Introduction to Materials Science

Atomistics (electronic structure)

Structure and concept of order in matter

Crystalline matter (lattices / perfect crystal and real crystal / crystalline defects + concept of microstructure)

Mechanical properties of crystalline materials (tensile test / elastic deformation / plastic deformation / fracture)

Electromagnetism:

Supplementary electrokinetics for magnetostatics

Lorentz force and Laplace force

Magnetostatics (Biot–Savart law, Ampère's theorem)

Introduction to electromagnetism: Quasi-static approximation (ARQS) and induction phenomena

Brief introduction to waves (general concepts, harmonic waves, progressive and stationary waves, interference and diffraction)

Prerequisite: Electrostatics
Supplementary Control Engineering:

This course deals with sequential logic. The general structure of a sequential system and basic sequential systems (counters, flip-flops) are studied. A method for designing synchronous sequential systems with implementation via flip-flops is covered.
This course prepares for and includes three practical lab sessions.

Objectives

Course Objective:
The aim of this course is to provide students with additional physics knowledge, especially for those who wish to continue their studies in AE (Automatic Engineering) or GP (General Physics).

The course covers three subjects:

Materials:
At the end of this course, students should be able to describe the main macroscopic mechanical properties of materials and identify their microscopic origins related to the structural arrangement of matter.

Electromagnetism:
Introduction to waves and induction phenomena.

Supplementary Control Engineering:
At the end of this module, the student should understand and be able to explain:

The concepts of sequential systems

The methods for designing and implementing these systems

The student should be able to:

Design a sequential logic system

Additionally, the student should have applied the concepts seen in Continuous Control:

System modeling

System performance analysis

Implementation of controllers

Necessary prerequisites

Electrostatics

Combinational Logic

Continuous Control

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Practical info

Location(s)

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Foreign language 1

Introducing

Description

Évaluation

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Practical info

Location(s)

Toulouse

Foreign language 2

Introducing

Description

Évaluation

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Practical info

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INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Professional Path Initiative 2nd Year

Introducing

Description

Évaluation

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Practical info

Location(s)

Toulouse

Introducing

Description

Évaluation

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Practical info

Location(s)

Toulouse