# YEAR 1
# COURSE OFFERING
## Fall Semester

# MATHEMATICS

## Linear Algebra MAA101

S. Bijakowski

ECTS Credits: 4
MANDATORY

Linear algebra (MAA101) is a fast-paced course which provides students with an overview of the most useful techniques of linear algebra. Upon completion of this course, students will fully understand the fundamental concepts of vector spaces, dimension, linear systems, and determinants, and how they apply to problems in other fields of the Bachelor program.

## Introduction to Analysis MAA102

F. Pacard

ECTS Credits: 4
MANDATORY

Introduction to analysis (MAA102) is an introductory-level mathematical analysis course that provides a well-balanced approach between calculus and foundational notions; it is designed to equip students with the fundamental analytical tools required in all scientific fields. In particular, this course covers derivatives and function approximation in one real variable. It also introduces students to important mathematical concepts which will be expanded upon later in the program; namely, the basics of topology on the real line.

# Discrete Mathematics MAA103

F. Alouges

ECTS Credits: 4
MANDATORY

Discrete Mathematics (MAA103) begins by introducing students to the central notions needed to pursue advanced mathematics, such as elementary logic (e.g. quantifiers, different methods of proof), sets, and functions. The second part of the course introduces students to combinatorics and probability (on finite sets). Course material is supplemented with examples and applications, such as graphical modeling and generating functions.

*For this course, students can request to have a Pass/Fail grade instead of a letter grade. Students who receive a Pass grade still benefit from the ECTS credits associated to the course but their grade does not count towards calculating their GPA. Students can make such a request for a maximum of two courses during Semester 1.*

# COMPUTER SCIENCE

## Computer Programming CSE101

B. Smith

ECTS Credits: 4
MANDATORY

Computer programming (CSE101) introduces students (with or without previous programming experience) to the fundamentals of computer programming in Python, with applications across the sciences. In this course, students will explore fundamental algorithms and data structures, up to and including binary trees, using a mixture of procedural, recursive, and object-oriented techniques. Upon completion of this course, students will have a solid foundation in the culture and practice of modern programming, and the basic skills to solve real-world problems using efficient, well-written programs and open-source tools. These foundations will be extended and completed in CSE 102 and CSE 103.

# ECONOMICS

## Introduction to Economics ECO101

Y. Koriyama, J-B. Michaud

ECTS Credits: 4
MANDATORY

Introduction to Economics (ECO101) provides students with the foundational concepts of economics. The course begins with the investigation of the individual behavior of households and firms. Subsequently, students review and develop a thorough understanding of the concepts of supply and demand, before investigating how markets function. The course also covers imperfect competition and other market failures, as well as macroeconomic aggregates and the role of the central bank.

**Required reading**: Principle of Economics by N. Gregory Mankiw

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# PHYSICS

## Physics I: Mechanics And Heat PHY101

S. Ramananarivo

ECTS Credits: 4
MANDATORY

Physics I (PHY101) introduces students to basis concepts in mechanics and thermodynamics. It first covers point-like and simple solids in various coordinate systems; while providing an overview of the fundamental law of dynamics, kinetic and potential energy, linear and angular momentum; central and conservative forces and mechanical work. Harmonic oscillators, resonance, and one dimensional waves are studied in this context. Kinetic theory of ideal gas introduces the basic thermodynamic concepts: heat, temperature, entropy, efficiency, state variables for closed system. Upon completion of this course, students will master basic equations and principles in classical mechanics and thermodynamics and will be able to derive and solve simple models taken from their environment.

*For this course, students can request to have a Pass/Fail grade instead of a letter grade. Students who receive a Pass grade still benefit from the ECTS credits associated to the course but their grade does not count towards calculating their GPA. Students can make such a request for a maximum of two courses during Semester 1.*

## Mathematical Methods for Physics I PHY102

C. Bellis

ECTS Credits: 2
MANDATORY

Mathematical Methods for Physics I (PHY 102) will enable students to acquire the mathematical skills that are mandatory for PHY 101 and PHY 104, and which will not be covered in the first year math courses. It covers a variety of mathematical concepts that pertains to real analysis and calculus, with the aim of familiarizing students with mathematical reasoning and developing their technical skills. The content covers fundamental calculus (usual functions, differentiation), vector algebra, coordinate systems, integration, first- and second-order differential equations, and partial differentiation.

# Beginner's Physics Lab I PHY103

C. Baroud, Y. Laplace

**Course description:** In the Beginner's Physics Lab sessions students will have the opportunity to apply the physics knowledge they have acquired in PHY 101 in 4 distinct lab sessions of 4 hour duration. Students will learn basic experimental techniques, data analysis and interpretation, and documentation of experimental work. PHY103 will cover harmonic oscillators, forces and equilibrium, kinematics and collisions, and waves.

ECTS Credits: 2
Mandatory for the double major Math/Physics, Eligible as a supplementary course

# CHEMISTRY

## General Chemistry CHE101

A. Auffrant

ECTS Credits: 3
Required for the Chemistry minor, Eligible as a supplementary course

General Chemistry (CHE101) covers fundamental concepts of atomic structure, and bonding within molecules. It also describes intermolecular interactions and their consequences regarding macroscopic properties. Students also explore the notion of orbital.

CHE101 aims to develop students' fundamental knowledge in chemistry for further study of reactivity aspects in higher-level courses.

This course will rely on concepts covered in physics related to the particle-wave duality of elementary particles in quantum mechanics.

# PERSONAL DEVELOPMENT

## Seizing my New Life at University PDV101

B. Destremau

ECTS Credits: 1
Eligible as a supplementary course

Transitioning from high school to university is an important step that touches all aspects of one's life: starting university, the student will discover a new approach to academics but also live a new life on campus with new type of relations with adults and peers.

This unit is designed to help the student get a good start in university life. It will take the form of group sessions with members of the academic team, a counsellor, coaches and/or the head of personal development. These sessions will focus on diverse questions the student might encounter on campus and especially on the question of choice. How can one make good choices for his/her life?

Students will share points of view, learn to discover each other and tackle methods to work, think and choose effectively.

# YEAR 1
# COURSE OFFERING
## Spring Semester

# MATHEMATICS

## Reduction of Endomorphisms MAA104

J. Fresán

ECTS Credits: 5
MANDATORY

**Prerequisite:** MAA101

Reduction of endomorphisms (MAA104) introduces students to more conceptual algebraic subjects. More precisely, students explore the fundamental structures of algebra including groups, rings, and fields. Topics covered in this course are designed to prepare students for later questions related to symmetry (including those arising in physics) and number theory. This course also covers the study of polynomials, including their application, to further develop techniques acquired from linear algebra.

## Integral and Differential Calculus MAA105

J. Bettinelli

ECTS Credits: 5
MANDATORY

**Prerequisite:** MAA102

Integral and differential calculus (MAA105) develops students' skills in two crucial analytical tools: Integration and Differential Equations. The approach to Integration employed in this course is Riemann's integral, a foundational mathematics theory. This course also introduces students to two important and related topics covered in the Bachelor program: differential equations which is required to understand basic physical problems (trajectories, populations, etc.), and geometry through the study of parametrized curves.

## Introduction to Numerical Analysis MAA106

**Prerequisites**: MAA102, MAA103

The aim of Introduction to Numerical Analysis (MAA106) is to provide students with practical knowledge of basic mathematic algorithms and computer programming. Computational Mathematics covers several notions such as representation of numbers, complexity of algorithms, interpolation of functions, numerical integration, optimization, error analysis, etc. The course's focus is on implementation using Python.

ECTS Credits: 3
Recommended for all double majors, Mandatory for the double major Math/CS, Eligible as a supplementary course

## Mathematical Modeling MAA107

V. Bansaye, T. Mastrolia

**Prerequisites**: MAA101, MAA102

Mathematical Modeling (MAA107) introduces the topic as it applies to physics, biology and economics. The course covers mathematical formalization which can be used to describe some dynamics related to the following topics: mechanical and biological systems, evolution of populations, pricing, contract theory, etc. Students learn to evaluate models and motivating questions, to determine how mathematics can provide quantitative or qualitative answers. To this end, the course introduces students to and develops tools and technics from dynamical systems (*e.g.* recurrence relation and ordinary differential equations) and random evolution (*e.g.* Markov chain on a finite state space and discrete martingale). The

ECTS Credits: 3
Eligible as supplementary course

# COMPUTER SCIENCE

## Computer Programming CSE102

P-Y. Strub

ECTS Credits: 5
MANDATORY

**Prerequisite:** CSE101

Computer Programming (CSE102) is the continuation of the previous semester's course (CSE101). We will continue to lay the foundations of modern computer science, while developing more sophisticated programming techniques in Python. At the end of this course, students will have the fundamental analytical and programming skills to solve everyday problems in the sciences more efficiently and effectively. They will also be prepared to continue learning other programming languages and paradigms, and the theoretical foundations of computer science itself.

## Introduction to Algorithms CSE103

I. Mackie

ECTS Credits: 3
Mandatory for the double major Math/CS, Eligible as a supplementary course

**Prerequisite:** CSE101

An algorithm is a sequence of instructions that allows us to solve a problem using a finite number of steps; as such, algorithms formalize the notion of what it means to "compute". We study algorithms to know what can actually be computed, in theory and in practice, and to find out how efficiently it can be done. Introduction to Algorithms (CSE103) is an initiation into the art and science of algorithms. This course will train students in how to think about algorithms, how to rigorously compare different algorithms and predict their performance, and how to apply this knowledge to solve computational problems efficiently.

# Web Programming CSE104

D. Rohmer

**Prerequisite**: CSE101

Web Programming (CSE104) introduces the languages, tools, and techniques specific to developing web-based applications. Students will develop a solid understanding of the intricacies of contemporary, dynamic website development, and an insight into the internal workings of the web itself. This is a hands-on practical course that provides students with valuable practice developing their own web-based applications.

ECTS Credits: 3

Recommended for the double major Math/CS, Eligible as a supplementary course

# ECONOMICS

## Topics in Economics ECO102

G. Barrows, A. Pérez-Baranoha, B.Schmutz

ECTS Credits: 3
Mandatory for the double major Math/ Economics, Eligible as a supplementary course, Not compatible with PHY107

Topics in Economics (ECO102) provides an overview of how the concepts in economic analysis are applied through the real-life examples of scientific research in economics. Students will learn how theoretical and empirical methods in economics are employed in the analysis of diverse subjects, such as economic growth, environmental regulation, public policy, networks, firms' behaviors, etc. Topics are chosen from the themes in the frontier of economic research.

# PHYSICS

## Physics II: Electromagnetism and Light PHY104

S. Corde

ECTS Credits: 5
Mandatory for the double major Math/Physics, Eligible as a supplementary course

**Prerequisites:** PHY105

Physics II (PHY104) provides an overview of numerous physics concepts related to the description of light and of electromagnetic phenomena. This course introduces the concept of fields in physics, in particular with the electric and magnetic fields, and develops students' understanding of electricstatics, magnetostatics, electrical circuits, geometrical and wave description of light. In addition, students explore concepts such as Coulomb's law, Lorentz force, Gauss' law, Ohm's law, Kirchhoff's circuit laws, Faraday's law, and others. Upon completion of the course, the students will understand how the classical field theory of electromagnetism with the set of Maxwell equations can describe in a unified way many physical phenomena, from the propagation of light to electrostatics, magnetostatics and electrical circuits.

## Mathematical Methods for Physics II PHY105

B. Goutéraux

ECTS Credits: 2
Mandatory for the double major Math/Physics, Eligible as a supplementary course

**Prerequisites:** PHY104

Mathematical Methods for Physics II (PHY105) builds upon the previous semester's course PHY102 and will provide the students with the necessary mathematical techniques for other Semester 2 courses, such as PHY104 and PHY107. The mathematical tools introduced will also be needed in later years, for instance in PHY202, PHY204, PHY206, PHY306 among others.

The course is divided in two main parts:

**i) Vector analysis.**

This part builds on the basics of vector algebra introduced in PHY102. Vectors are objects of fundamental importance to describe physical phenomena.

Mathematical tools: partial derivatives, total differentials, surface and volume integrals, vector differential operators (gradient, divergence, rotational), line integrals, Green's theorem in the plane, divergence and Stokes' theorem.

**ii) Fourier analysis.**

Physics problems often involve solving partial differential equations (wave equation, heat equation, Schroedinger equation…). Such equations are very difficult to solve analytically without approximations, and often numerical calculations are needed. However, under certain assumptions, some functions (loosely, periodic func-

# PHYSICS

tions) can be developed in a Fourier series and can be found approximately to a very high accuracy. In this part of the course, we will introduce the basics of Fourier series and how they can be used to solve partial differential equations. Mathematical tools: Dirichlet conditions, Fourier series expansion in the cosine-sine/complex exponential bases, Parseval's theorem.

## Beginner's Physics Lab II PHY106

Y. Laplace

ECTS Credits: 2
Mandatory for the double major Math/Physics, Eligible as a supplementary course

**Prerequisites**: MAA101 and MAA102
In the Beginner's Physics Lab sessions, students will have the opportunity to apply the phyics knowledge they have acquired in PHY104 in five distinct lab sessions of 4-hour duration. Students will learn basic experimental techniques, data analysis and interpretation, and documentation of experimental work. Students will cover, in-depth, the measurement of the speed of light, the measurement of the specific charge (e/m) of the electron, the photoelectric effect and the measurement of the Planck constant, as well as the Franck-Hertz experiment.

## Applied Physics PHY107

S. Starikovskaia

ECTS Credits: 3
Recommended for the double major Math/Physics, Eligible as a supplementary course, Not compatible with ECO 102

Applied Physics (PHY107) provides a combination of lectures and seminars with a clear aim to show the link between advanced engineering and high-level physical/mathematical education. The course will cover selected questions based on fluid mechanics, thermodynamics, optics, electricity and magnetism. Background obtained during courses of general physics and mathematics will be used to understand the principles of rocket propulsion, engines for hypersonic flights, peculiarities of mass-spectrometry in physics/chemistry and biology, the link between optical spectroscopy, molecular analysis and quantum mechanics etc. As a result of the course, students should be able to look at applied physics problems combining deep knowledge in mathematics and physics and to be able to formulate to resolve a set of estimates giving the idea about mechanisms involved in the considered phenomena.

# BIOLOGY

## Biology BIO101

C. Le Clainche

Biology (BIO101) is a molecular and cellular biology course, which provides all the concepts required for a scientific understanding of living systems. This course aims both at preparing students for the biology option, which is available in the Mathematics & Computer Science and Mathematics & Physics majors, and at raising awareness about socio-economic issues related to biology, such as health, ethics or bioengineering.

ECTS Credits: 3
Required for the Biology minor, Eligible as a supplementary course

# HUMANITIES AND SOCIAL SCIENCES

## Major Issues in Today's World and the Place of France HSS101

N. Rousselier

ECTS Credits: 2
Eligible as a supplementary course

HSS101 is designed to give a broad and comprehensive view of the political and social place of France in today's globalized world. Two themes will be addressed this year in order to understand the originality of French Politics. First, we will study the question of the French democracy and its difficulties. French Politics have gone through many different political regimes (Monarchy under different styles, two Bonapartist Empires, five different forms of Republic, Vichy's Dictatorship) and recurrent upheavals from the Revolution of 1789 to the "Gilets Jaunes" of 2018. It is this "French instability" which is at the core of the first part of the course. Secondly, the course will address issue of the French Secularism, "laïcité à la française". It was historically and is still today one of the great challenges of French society and the French democracy.

# PERSONAL DEVELOPMENT

## Meeting Professionals PDV102

B. Destremau

In this unit, the students will interview a professional of their choice and present what they have learnt to their peers who will assess their presentation. Discussion will follow. It will help all students better their communication skills and reflect upon academic and career choices. Depending on the number of students, unformal meetings/tea parties with additional professionals chosen by the DFHM will follow.

ECTS Credits: 1
Eligible as a supplementary course