École Polytechnique Bachelor Program

Syllabus – YEAR 1

This syllabus contains all the first-year courses of École Polytechnique's Bachelor Program.

This document contains the following information:

- a description of academic content and course objectives
- a series of tables listing the course offerings by semester
- a short description of each course, along with the instructor's name and, if required, bibliographic recommendations.

Note:

- In each course, students are assessed through coursework including take-home assignments, group work, quizzes, and/or final exams. In courses which contain a final exam, the exam can be worth no more than 50% of the overall grade.
- The course descriptions and list of professors contained in this document will be updated yearly.

SEMESTER 1

Course	Average hours per week	Hours per semester	ECTS Credits	Professor(s)
Science Courses				
Mathematics	10	150	12	S. Bijakowski I. Kortchemski Y. Martel
Physics & Mathematical Methods	5.5	84.5	6	J-M. Allain D. Clouteau
Computer Science	3.5	52.5	5	B. Smith
Economics	2.5	37.5	3	Y. Koriyama J-B Michaud
Elective Science Courses *(required to complete a minor)*				
Chemistry	2	34	2	A. Auffrant
Other Courses				
Culutral Field Trip	-	9	1	N. Wanlin A. Reavley J. André
Foreign Languages	2 to 4	30 to 64	2 to 4	TBD - Chinese S. Brown – English C. Robinson – English J. André – French I. Schaffner – French A. Reavley – French D. Argeles – German H. Knörzer – German TBD – Italian TBD - Japanese M. Buisson– Spanish
Sports	2	30	1	
Personal Development	2 (every other week)	14	1	

MATHEMATICS (12 ECTS)

Algebra (MAA 101)
Instructor: S. Bijakowski
ECTS Credits: 4

Course description: Algebra (MAA 101) 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.

Analysis (MAA 102)
Instructor: Y. Martel
ECTS Credits: 4

Course description: Analysis (MAA 102) 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 (MAA 103)
Instructor: I. Kortchemski
ECTS Credits: 4

Course description: Discrete Mathematics (MAA 103) 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.

PHYSICS (6 ECTS)

Physics I : Mechanics And Heat (PHY 101)
Instructor: D. Clouteau
ECTS Credits: 4

Course description: Physics I (PHY 101) 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, free and forced oscillations, resonance, eigenmodes, 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, phase change 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.

Mathematical Methods for Physics I (PHY 102)
Instructor: D. Clouteau
ECTS Credits: 1

Course description: Mathematical Methods for Physics I (PHY 102) will provide students with those mathematical skills that are mandatory for PHY101 and PHY 104, and that will not be covered by the first year math courses. It covers a variety of mathematical concepts including special functions, vector algebra, dot product, cross product, complex numbers, full and partial derivatives, simple and multiple integrals, integration techniques (substitution, by parts), linear ODE 1st and 2nd order, vector

spaces, vector-valued functions, Fourier series, gradient and divergence operators, basic statistics and probability.

Beginner's Physics Lab I (PHY 103)
Instructor: J-M. Allain
ECTS Credits: 1

Course description: In the Beginner's Physics Lab sessions students will have the opportunity to apply the physics knowledge they have acquired in PHY101 in 4 distinct lab sessions of 4 hour duration. Students will learn basic experimental techniques, data analysis and interpretation, and documentation of experimental work. PHY 103 will cover harmonic oscillators, forces and equilibrium, kinematics and collisions, and waves.

COMPUTER SCIENCE

Computer Programming (CSE 101)
Instructor: B. Smith
ECTS Credits: 5

Course description: Computer programming (CSE 101) 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 (ECO 101)
Instructors: Y. Koriyama / J-B. Michaud
ECTS Credits: 3

Course description: Introduction to Economics (ECO 101) 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 macherket failures, as well as macroeconomic aggregates and the role of the central bank.

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

CHEMISTRY (ELECTIVE)

General Chemistry (CHE 101)
Instructor: A. Auffrant
ECTS Credits: 2

Course description: General Chemistry (CHE 101) 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.

CHE 101 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.

SEMESTER 2

Course	Average hours per week	Hours per semester	ECTS Credits	Professor(s)
Mandatory Science Courses				
Mathematics	9	135	10	J. Bettinelli J. Fresán F. Golse A. Lefebvre-Lepot B. Stroh
Physics & Mathematical Methods	6	88.5	6	S. Corde B. Goutéraux Y. Laplace
Computer Science	5.5	82.5	6	K. Chaudhuri H. Zhou
Elective Science Courses : Up to two choices, including one mandatory & one optional course				
Mathematics	1.5	22.50	2	V. Bansaye T. Mastrolia
Physics	2	30	2	S. Starikovskaia
Computer Science	2	30	2	D. Rohmer
Economics	2	30	2	G. Barrows A. Pérez-Baranoha B.Schmutz
Biology (*required for the Biology minor*)	2	30	2	C. Le Clainche
Other Courses				
Cultural Field Trip	-	8	1	N. Roussellier
Foreign Languages	2	30	2	TBD - Chinese S. Brown – English C. Robinson – English J. André – French A. Reavley – French D. Argeles – German H. Knörzer – German TBD – Italian TBD - Japanese M. Buisson– Spanish
Humanities & Social Sciences	2	30	2	N. Roussellier
Sports	2	30	1	
Personal Development	2 (every other week)	14	1	

MATHEMATICS (10 ECTS)

Algebra (MAA 104)
Instructor: B. Stroh / J. Fresán
ECTS Credits: 4

Course description: Algebra (MAA 104) 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.

Analysis (MAA 105)
Instructor: F. Golse / J. Bettinelli
ECTS Credits: 4

Course description: Analysis (MAA 105) 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.

Computational Mathematics (MAA 106)
Instructor: A. Lefebvre-Lepot
ECTS Credits: 2

Course description: The aim of Computational Mathematics (MAA 106) 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.

PHYSICS (6 ECTS)

Physics II: Electromagnetism and Light (PHY 104)
Instructor: S. Corde
ECTS Credits: 4

Course description: Physics II (PHY 104) provides an overview of numerous physics concepts related to the description of light and of electromagnetic phenamena. 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 (PHY 105)
Instructor: B. Goutéraux
ECTS Credits: 1

Course description: Mathematical Methods for Physics II (PHY 105) builds upon the previous semester's course PHY 102. The necessary mathematical techniques for PHY104 and PHY107 will further develop students' knowledge of statistics, probability, Fourier analysis Vector analysis, gradient, divergence, curl, line integrals, partial differential equations, and surface integrals, while introducing students to Gauss' theorem and Stokes' theorem.

Beginner's Physics Lab II (PHY 106)
Instructor: Y. Laplace
ECTS Credits: 1

Course description: 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. PHY106In this lab will cover, in-depth, the measurement of the speed of light, fiber-optical communication, measurement of e/m of the electron, photoelectric effect, as well as measurement of the Planck constant, and the Franck-Hertz experiment.

COMPUTER SCIENCE (6 ECTS)

Computer Programming (CSE 102)
Instructor: K. Chaudhuri
ECTS Credits: 3

Course description: Computer Programming (CSE 102) is the continuation of the previous semester's course (CSE 101). 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 (CSE 103)
Instructor: H. Zhou
ECTS Credits: 3

Course description: 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 (CSE 103) 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.

BIOLOGY (ELECTIVE)

Biology (BIO 101)
Instructor: C. Le Clainche
ECTS Credits: 2

Course description: Biology (BIO 101) 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.

MATHEMATICS (ELECTIVE)

Mathematical Modeling (MAA 107)
Instructor. Bansaye / T. Mastrolia
ECTS Credits: 2

Description course: Mathematical Modeling (MAA 107) 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 concepts of optimization and stability are also covered.

PHYSICS (ELECTIVE)

Applied Physics (PHY 107)
Instructor: S. Starikovskaia
ECTS Credits: 2

Course description: 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.

COMPUTER SCIENCE (ELECTIVE)

Web Programming (CSE 104)
Instructor. Rohmer
ECTS Credits: 2

Course description : Web Programming (CSE 104) 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.

ECONOMICS (ELECTIVE)

Topics in Economics (ECO 102)
Instructors: G. Barrows / A. Pérez-Baranoha / B.Schmutz
ECTS Credits: 2

Course description: Topics in Economics (ECO 102) 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.

HUMANITIES AND SOCIAL SCIENCES

Major Issues in Today's World and the Place of France (HSS 101)
Instructor(s) : N. Roussellier
ECTS Credits: 2

Course description: HSS 101 is designed to give a broad and comprehensive view of the political, economic and cultural place of France in today's globalized world. It introduces the basics of international economics and international relations, with a particular focus on France, both from an institutional and "balance of power" perspective. Through the study of modern history and current events, students compare the French political system and its society to the countries with which France interacts, especially within the European Union. The course's goal is to enable students to confront today's changing world and to become agents of change.