CentraleSupélec

Course catalogue

Computer Science Engineer

Third year

Metz Campus of CentraleSupélec

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Semester 9

ISP-INF-S09-09		**Computer Science 2 S08**	**9.5 ECTS**
SPM-INF-022	*2.5*	*Mobile Applications: Strategies and Implementation*	*27.0 h*
SPM-INF-020	*2.5*	*HPC-HPDA on clusters of multi-cores*	*27.0 h*
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SPM-INF-019	2.5	Cybersecurity elements	29.5 h
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ISP-INF-S09-10		**Computer Science 1 S08**	**6.5 ECTS**
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3MD4030	2	HPC-HPDA on GPU with CUDA	22.5 h
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ISP-INF-S09-11		**Final Project S09**	**7 ECTS**
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ISP-INF-S09-25		**HEP S09**	**3 ECTS**
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SPM-HEP-015	1	Innovation	35.0 h

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Semester 10

ISP-INF-S10-12		**Final Project S10**	**4 ECTS**
SPM-PRJ-013	1	Final project	42.0 h

ISP-INF-S10-13		**Artificial Intelligence S10**	**7 ECTS**
3MD4120	*2*	*Reinforcement learning*	*23.0 h*
SPM-INF-018	*2*	*Advanced databases*	*23.0 h*
3MD4150	3	Natural language processing	36.0 h
3MD4110	2	Perspectives in Learning and Artificial Intelligence	23.5 h

ISP-INF-S10-26		**HEP S10**	**2 ECTS**
SPM-HEP-007	1	Financial management	15.0 h
SPM-HEP-022	1	Management	19.0 h

ISP-INF-S10-14		**End-of-studies Internship**	**15 ECTS**
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ISP-INF-S10-20		**Foreign Language S10**	**2 ECTS**
LV1S10	1	Foreign Languages and Culture 1	11.5 h
LV2S10	1	Foreign Languages and Culture 2	11.5 h

Mobile Applications: Strategies and Implementation

Course supervisor: Virginie Galtier

Total: 27.0 h (optional) **CM:** 6.0 h, **TP:** 20.0 h

SPM-INF-022 *back*

Description: This course is an introduction to mobile application development. It presents different strategies for mobile development (native, web and progressive web apps, hybrid, MBaaS), along with the associated publishing options, and illustrates two of these strategies through hands-on implementation (currently planned: native development with Android and hybrid development with Flutter).

Learning outcomes: By the end of this course, students will be able to select a mobile application development strategy and develop simple applications using two different approaches.

Evaluation methods: 1h written test

Evaluated skills:
- Development

CM:

1. introduction : les différentes stratégies pour le mobile (3.0 h)
2. introduction à Android (1.5 h)
3. introduction à Flutter (1.5 h)

TP:

1. développement natif (7.0 h)
2. développement cross-platform (7.0 h)
3. processus de test et publication (6.0 h)

HPC-HPDA on clusters of multi-cores

Course supervisor: Stéphane Vialle

Total: 27.0 h (optional) **CM:** 10.5 h, **TD:** 1.5 h, **TP:** 15.0 h

SPM-INF-020 *back*

Description: Programming in MPI+multithreading and use of a multi-core PC cluster for high-performance computing (HPC) and high-performance data analysis. Study of point-to-point and collective MPI communications, mechanisms for controlling the deployment of MPI+multithreading applications on multi-core node clusters. Distributed algorithms for 1D, 2D, and hypercubic problems, synchronous and asynchronous distributed algorithms. Learning how to submit distributed applications in batch mode. Review of performance metrics (speedup, efficiency, size up, scale up) and theoretical performance models; case studies. Implementation on linear algebra problems (HPC), then on a data clustering problem (HPDA), with measurement and analysis of performance and scalability.

Learning outcomes: At the end of this course, students will be able to design distributed algorithms that combine message passing between processes on different computing nodes and multithreaded programming through memory sharing within a process. They will be able to deploy these hybrid codes on multi-core node clusters, search for the most efficient deployments, and measure and analyze their performance. They will have applied this knowledge to traditional HPC calculations and to a less conventional AI problem. In both cases, they will have faced a problem of "scaling" their codes.

Evaluated skills:
- Development
- System

CM:

1. Cours d'architectures distribuées (1.5 h)
2. Programmation MPI en comm pt-a-pt (1.5 h)
3. Programmation MPI en comm collectives (1.5 h)
4. Déploiement d'application MPI sur cluster de multi-coeurs (1.5 h)
5. Rappels de métriques de performance, et modèles de performances théoriques (1.5 h)
6. Algorithmique et programmation distribuée synchrone (1.5 h)
7. Algorithmique et programmation distribuée asynchrone (1.5 h)

TD:

1. TD-MPI-Clustering (1.5 h)

TP:

1. TP-MPI pb 1D synchrone en MPI+OpenMP et déploiement (3.0 h)
2. TP-MPI pb 2D synchrone en MPI+OpenMP et déploiement (3.0 h)
3. TP-MPI pb asynchrone en MPI+OpenMP et déploiement (3.0 h)
4. TP-MPI-Clustering - part 1 (3.0 h)
5. TP-MPI-Clustering - part 2 (3.0 h)

Deductive systems logic

Course supervisor: Benoît Valiron

Total: 24.0 h **CM:** 12.0 h, **TD:** 3.0 h, **TP:** 9.0 h

SPM-INF-021 *back*

Description: The objective is to present logic as a modeling tool, to show that it can be used to solve problems without coding in a traditional programming language, and that it can also be used to model the semantics of programs and prove correctness and termination, which leads to the third block: specification/verification/proof. We will cover SAT and SMT solvers and program proof, with practical implementation exercises.

Learning outcomes: At the end of this course, students will have made the connection between the theoretical aspects of logic and computer science, paving the way for certified computer science.

Evaluated skills:

- Certification

CM:

1. Leçon de choses (3.0 h)
2. Logique propositionnelle, fonctionnement d'un solveur SAT (3.0 h)
3. Extension avec des types, notion de théorie, fonctionnement d'un SMT (3.0 h)
4. Logique de Hoare: logique sur les types du langage de programmation. (1.5 h)
5. Calcul des plus faibles préconditions (WP), chainage, obligations de preuves. (1.5 h)

TD:

1. Logique de Hoare (1.5 h)
2. Exemple de dérivation (1.5 h)

TP:

1. Ecriture d'un solveur SAT (3.0 h)
2. Utilisation de Z3 (3.0 h)
3. Outil Why3, exemple avec un calcul sur des entiers. (3.0 h)

Cybersecurity elements

Course supervisor: Hervé Frezza-Buet

Total: 29.5 h **CM:** 13.5 h, **TP:** 16.0 h

SPM-INF-019 *back*

Description: Security concepts (confidentiality, integrity, availability, authentication, encryption, vulnerability, denial of service, etc. essential vocabulary), cryptography (theory, important algorithms AES, RSA), network security (firewalls, VPN), software security (security of C and Java languages), operating system security (password management, Active Directory, OS protection mechanisms), web security (injections, XSS, ...), risk analysis (EBIOS, PCA, PRA). Possibly blockchain and virology.

Learning outcomes: Without becoming cybersecurity experts, students will have gained a solid overview of the field by the end of this course, which they can then use as a basis for further study.

Evaluated skills:
- System

CM:

1. Cours-1 (1.5 h)
2. Cours-2 (1.5 h)
3. Cours-3 (1.5 h)
4. Cours-4 (1.5 h)
5. Cours-5 (1.5 h)
6. Cours-6 (1.5 h)
7. Cours-7 (1.5 h)
8. Cours-8 (1.5 h)
9. Cours-9 (1.5 h)

TP:

1. TP-1 (4.0 h)
2. TP-2 (4.0 h)
3. TP-3 (4.0 h)
4. TP-4 (4.0 h)

Statistical models 2

Course supervisor: Frédéric Pennerath

Total: 33.0 h **CM:** 12.0 h, **TD:** 6.0 h, **TP:** 12.0 h

3MD4050 *back*

Description: This course is an extension of the ModStat1 course. It is structured around the three fundamental concepts of stochastic processes, latent variables and approximate inference techniques. The first part of the course on processes focuses on three main families of processes: point processes, Markov processes and Gaussian processes. The notion of latent variable is then addressed through mixture models and the EM algorithm. The two notions are then combined to develop hidden Markov models, for both discrete (HMM) and continuous states (Kalman filters). Finally, approximate inference techniques are presented, with sampling techniques (MCMC) and variational inference.

Prerequisites: - Having followed the course "Statistical Models 1" - Beginner level in Python / Numpy programming

Learning outcomes: At the end of this course, students will be able to associate the corresponding type of stochastic process with data series and apply the associated estimation methods. They will also be able to specify a model incorporating hidden variables and apply the EM algorithm to estimate its parameters. They will be able to model a clustering problem in the form of a mixture model. They will be able to specify an HMM or a Kalman filter to model the dynamic behavior of a discrete or continuous state system.

Evaluation methods: 3h written test with documents, can be retaken.

Evaluated skills:
- Modelling
- Research and Development

CM:

1. Processus ponctuels (1.5 h)
2. Processus de Markov (1.5 h)
3. Processus gaussiens (1.5 h)
4. Modèles de mélanges (1.5 h)
5. Modèles de Markov cachés (1.5 h)
6. Filtre de Kalman (1.5 h)
7. Echantillonnage (1.5 h)
8. Inférence variationnelle (1.5 h)

TD:

1. Processus de Poisson et de Markov (1.5 h)
2. Modèles de Markov cachés (1.5 h)
3. Filtre de Kalman (1.5 h)
4. Echantillonnage (1.5 h)

TP:

1. Processus gaussiens (3.0 h)
2. Modèles de mélange (3.0 h)
3. Filtre de Kalman et particul. (3.0 h)
4. Echantillonnage (3.0 h)

Machine learning 2

Course supervisor: Arthur Hoarau

Total: 21.5 h **CM:** 10.5 h, **TP:** 9.0 h

3MD4010 *back*

Description: This course complements Machine Learning 1 with notions of data processing (dimension reduction, etc.), unsupervised learning, active and semi-supervised learning, explicability issues.

Learning outcomes: By the end of this course, students will have completed their breadth approach to machine learning.

Evaluation methods: 2h written test, can be retaken.

Evaluated skills:
- Research and Development
- Development

CM:

1. Réduction de dimension (1.5 h)
2. Partitionnement (1.5 h)
3. Quantification vectorielle (1.5 h)
4. Détection anomalies (1.5 h)
5. Apprentissage semi-supervisé (1.5 h)
6. Apprentissage actif (1.5 h)
7. Explicabilité (1.5 h)

TP:

1. Réduction de dimension (3.0 h)
2. Apprentissage non supervisé (3.0 h)
3. Apprentissage semi-supervisé (3.0 h)

HPC-HPDA on GPU with CUDA

Course supervisor: Stéphane Vialle

Total: 22.5 h **CM:** 6.0 h, **TD:** 4.5 h, **TP:** 12.0 h

3MD4030 *back*

Description: This course aims to introduce high performance algorithmics and programming on GPU, with experiments on Machine Learning algorithms run on GPU servers.

Content: GPU architecture Algorithmic principles of fine grained GPU parallelism (SIMD and SIMT models) CUDA programming Usage of CUBLAS library Optimization of GPU and CPU-GPU CUDA codes Design and experiment of K-means algorithms on GPU

Prerequisites: 1st year common course: "Systèmes d'Information et Programmation" (1CC1000) 1st year common course: "Algorithmique & Complexité" (1CC2000) C++ Advanced programming course (3MD1020) of SDI mention at Metz Automatic Learning course (3MD1040) of SDI mention at Metz

Learning outcomes: At the end of this course, students will be able: Learning Outcome AA1: to analyse the adequacy of a mathematical solution with an implementation and execution on GPU, Learning Outcome AA2: to design a GPU algorithm, or to adapt an algorithm to increase its efficiency on GPU, Learning Outcome AA3: to design hybrid algorithms for CPU-GPU systems, overlapping data transfers and computations, Learning Outcome AA4: to implement algorithms and to debug codes on GPU, Learning Outcome AA5: to analyse and to summarize GPU software.

Means: Development and execution platform: GPU servers of the Data Center for Education of CentraleSupélec Metz Campus. NVIDIA CUDA development environment.

Evaluation methods: Evaluation of Lab results about parts 2 and 3, and final and individual exam Reports of the Lab about parts 2 and 3 (the content and the number of pages of the reports are constrained, in order to force the students to an effort of synthesis and clarity) In the event of unjustified absence from a practical work, the mark of 0 will be applied, in the event of justified absence the average mark of other labs will be applied. The remedial exam will be a 1 hour oral exam, which will constitute 100

Evaluated skills:
- Development

CM:

1. Architecture des GPU (1.5 h)
2. Bases d'algorithmique de programmation CUDA (1.5 h)
3. Coalescence et mémoire partagée (1.5 h)
4. Optimisations avancées en CUDA (1.5 h)

TD:

1. Conception et estimation de performances d'un code CUDA (1.5 h)
2. Optimisation et accélération d'un code CUDA (1.5 h)
3. K-means sur GPU (1.5 h)

TP:

1. Produit de matrices en CUDA : implantation et expérimentation (3.0 h)
2. Produit de matrices en CUDA : optimisation et mesure de gain (3.0 h)
3. K-means sur GPU : conception, implantation et expérimentation (3.0 h)

4. K-means sur GPU : optimisations multiples (3.0 h)

Web technologies

Course supervisor: Michel Ianotto

Total: 27.0 h (optional) **CM:** 9.0 h, **TP:** 17.0 h

SPM-INF-024 *back*

Description: This course focuses on the design and creation of dynamic websites. For the frontend part, we will introduce HTML, CSS, and JavaScript, which are used to structure web pages. On the backend side, we will present the MVC architecture through a 3-tier application accessing a MySQL database. Access to the DBMS will be via an ORM. A web application development framework will also be presented. On the development side, continuous integration and deployment tools will be implemented. The web application will be deployed in the cloud.

Learning outcomes: At the end of this course, students will have acquired basic knowledge of web technologies and will be able to manage and/or carry out a web application development project on both the frontend and backend sides.

Evaluated skills:
- Development

CM:

1. Concepts de base des applications Web (1.5 h)
2. Langages utilisés côté client (1.5 h)
3. L'authentification (session et cookies) (1.5 h)
4. Les Architecture 3-tiers et le modèle MVC (1.5 h)
5. Présentation d'un framework de développement d'applications Web (1.5 h)
6. Intégration continue et déploiement d'une application Web dans le cloud (1.5 h)

TP:

1. Développement de la partie frontend d'une application (4.0 h)
2. L'authentification (session et cookies) (3.0 h)
3. Les Architecture 3-tiers et le modèle MVC (3.0 h)
4. Développement de la partie backend d'une application et présentation d'un framework de développement d'applications Web (3.0 h)
5. Intégration continue (qualité du code, tests) et déploiement d'une application Web dans le cloud (4.0 h)

Safe software Development

Course supervisor: Idir Ait Sadoune

Total: 27.0 h (optional) **CM:** 13.5 h, **TD:** 7.5 h, **TP:** 6.0 h

SPM-INF-023 *back*

Description: This course will enable students to discover the basic concepts of the formal Event-B method through modeling and proof activities using Atelier Rodin, the main IDE for the Event-B method. The application of a top-down specification approach will enable students to use refinement, which is one of the basic operations of the Event-B method, and automatically generate verified C code that complies with the initial specification. The animation of Event-B models using the ProB tool is also covered. Finally, to cover the verification needs of existing critical code, formal verification techniques will also be presented and put into practice with the WP and MetAcsl plugins of the Frama-C platform.

Learning outcomes: At the end of this course, students will be able to apply a complete critical software development process, from specification to automatic source code generation.

Evaluated skills:
- Development
- Certification

CM:

1. Introduction à la méthode Event-B (1.5 h)
2. L'activité de preuve dans la méthode Event-B (1.5 h)
3. Le raffinement d'un modèle Event-B (1.5 h)
4. Introduction au Model-Checking (1.5 h)
5. Validation d'une spécification Event-B par Model-Checking (1.5 h)
6. Spécification et vérification formelle avec Frama-C/WP (3.0 h)
7. Vérification formelle de propriété de sécurité avec Frama-C/MetAcsl (3.0 h)

TD:

1. Introduction à la méthode Event-B (1.5 h)
2. L'activité de preuve dans la méthode Event-B (1.5 h)
3. Le raffinement d'un modèle Event-B (1.5 h)
4. Introduction au Model-Checking (1.5 h)
5. Validation d'une spécification Event-B par Model-Checking (1.5 h)

TP:

1. Etude de cas - s1 (3.0 h)
2. Etude de cas - s2 (3.0 h)

Final project

Course supervisor: Hervé Frezza-Buet

Total: 72.0 h **Projet:** 72.0 h

SPM-PRJ-012 *back*

Description: Final year project, completed at engineer/researcher level. This project focuses on topics related to research and development and prospective studies, and is similar to master's research projects in terms of the topics covered, the bibliographic research required, and the presentation of results.

Learning outcomes: The final year project is a successful research and development engineering experience, comparable in its methodology and forward-looking aspects to a master's research project.

Evaluated skills:

- Development
- Modelling
- Management
- Research and Development

Legal and regulatory systems

Course supervisor: Damien Rontani, Hervé Frezza-Buet

Total: 12.0 h **CM:** 6.0 h, **TD:** 6.0 h

SPM-HEP-020 *back*

Description: The objective of this course, through a concrete example, is to help students become familiar with the regulatory environment of engineers. One lecture will present the services of the State and their relationships with local authorities, as well as the different levels of regulations. A practical session will allow students to work on a real case, such as the installation of a photovoltaic field, a biogas plant, a wind farm, etc.

Learning outcomes: By the end of this course, students will have acquired knowledge of the legal and regulatory systems that influence engineering practice, particularly those governing environmental protection and ecological transition.

Evaluation methods: Assessment will be based on the summary report written according to the guidelines provided in the tutorials, using the documents studied.

CM:

1. Acteurs et instruments de la transition énergétique (3.0 h)
2. Appréhender les grands ensembles normatifs (3.0 h)

TD:

1. présentation du projet (1.5 h)
2. identifier les démarches à accomplir (urbanisme, environnement) et les interlocuteurs (3.0 h)
3. rédaction de la note de synthèse (1.5 h)

Innovation

Course supervisor: Ninel Kokanyan

Total: 35.0 h **CM:** 17.0 h, **TD:** 16.0 h

SPM-HEP-015 *back*

Description: If innovation is a driver of progress, it is above all a driver of economic growth. Driven by entrepreneurs and intrapreneurs, it must develop today for the benefit of citizens and the environment: "Innovation for Good" summarizes the motto. Innovation is also an adventure, a risky bet in an unknown environment. But entrepreneurs have tools and methodologies that allow them to navigate, reduce risks, and turn their vision into value for themselves and for society. The objective of this course is to familiarize students with these tools, giving them the means to embark on the entrepreneurial journey. The course follows the same logic as innovation projects, from idea generation and ideation to funding and market launch. It alternates between presenting concepts and applying them to innovation projects proposed by the students themselves. The module is assessed through a final start-up pitch, which crystallizes the acquisition of all the concepts presented.

Learning outcomes: By the end of this course, students will have mastered tools and methodologies for creative development, understand the legal framework to protect and enhance innovation, and acquire the skills necessary to carry out innovative projects within a company or as an entrepreneur.

Evaluation methods: Each group will pitch their project for 5 minutes in front of a jury composed of the various instructors. Assessment will focus on the quality and content of the pitch, as well as on the project files, which includes the different elements developed during each session and constitutes a coherent argument describing the project's value, innovative aspects, and feasibility.

CM:

1. Introduction : L'entrepreneur et l'intrapreneur au cœur de la destruction créative comme moteur de l'innovation. (2.0 h)
2. Design Thinking, de l'idéation au prototype. (2.0 h)
3. Eléments d'éco-design et innovation. (1.0 h)
4. Le business model canvas comme outil de visualisation des projets d'innovation. (2.0 h)
5. L'innovation ouverte comme accélérateur d'innovation. (3.0 h)
6. Protéger l'innovation grâce aux outils de la PI. (2.0 h)
7. L'innovation et le droit des entreprises : créer son entreprise. (2.0 h)
8. Créer son business plan et rechercher des financements. (2.0 h)
9. Pitcher son projet comme une start-up : outils. (1.0 h)

TD:

1. Créativité et problématisation des projets d'innovation. Brainstorming et Value-Proposition Canvas (2.0 h)
2. Créativité et Design thi'nk'ing, vers un premier prototype par groupe projet (2.0 h)
3. La fresque du numérique et l'impact environnemental du numérique (3.0 h)
4. Créativité et Design thi'nk'ing, suite du prototype par groupe projet (4.0 h)
5. Mise en pratique du BMC dans les contextes des groupes projet (2.0 h)
6. Pitch des BMC devant jury (1.0 h)
7. Pitcher son projet comme une start-up : outils, atelier et mise en pratique. (2.0 h)

Foreign Languages and Culture 1

Course supervisor: Elisabeth Leuba

Total: 21.0 h **TD:** 21.0 h

LV1S09 *back*

Description: The first foreign language is generally English. Students are divided into level groups ; in class, work is not only focused on the 4 language competences but also on various topics studied in depth according to students' levels. Topics cover a range of fields, such as civilisation, society and the professional world. Limited class size enables active participation and significant improvement in the language. The educational approach is varied: group work, class presentations, specific exercises, research, debates, etc.

Learning outcomes: At the end of the course, students will have improved their ability to communicate in an international professional, academic or personal context.

Evaluation methods: Assessment will be by continuous assessment according to criteria to be determined by each teacher, taking into account personal investment in the course. Each course will be marked out of 20 at the end of the semester.

Evaluated skills:

- Research and Development
- Consulting
- Business Intelligence
- Management

TD:

1. Cours (21.0 h)

Foreign Languages and Culture 2

Course supervisor: Beate Mansanti

Total: 21.0 h **TD:** 21.0 h

LV2S09 *back*

Description: Students are offered a range of second foreign languages at different levels, including for beginners. Students are divided into level groups; in class, work is not only focused on the 4 language competences but also on various topics studied in depth according to students' levels. Topics cover a range of fields, such as civilisation, society and the professional world. Limited class size enables active participation and significant improvement in the language. The educational approach is varied: group work, class presentations, specific exercises, research, debates, etc.

Learning outcomes: At the end of the course, students will have improved their ability to communicate in an international professional, academic or personal context.

Evaluation methods: Assessment will be by continuous assessment according to criteria to be determined by each teacher, taking into account personal investment in the course. Each course will be marked out of 20 at the end of the semester.

Evaluated skills:
- Research and Development
- Consulting
- Business Intelligence
- Management

TD:

1. Cours (21.0 h)

Final project

Course supervisor: Hervé Frezza-Buet

Total: 42.0 h **Projet:** 42.0 h

SPM-PRJ-013 *back*

Description: Final year project, completed at engineer/researcher level. This project focuses on topics related to research and development and prospective studies, and is similar to master's research projects in terms of the topics covered, the bibliographic research required, and the presentation of results.

Learning outcomes: The final year project is a successful research and development engineering experience, comparable in its methodology and forward-looking aspects to a master's research project.

Evaluated skills:
- Development
- Modelling
- Management
- Research and Development

Reinforcement learning

Course supervisor: Hervé Frezza-Buet

Total: 23.0 h (optional) **CM:** 9.0 h, **TD:** 3.0 h, **TP:** 9.0 h

3MD4120 *back*

Description: The course presents the theoretical foundations of reinforcement learning as well as the principles of the most common algorithms. Through practical work, these elements will be extended to more complex situations, making it possible to introduce the most recent algorithms that have, for example, enabled computers to master the game of Go.

Content: Reinforcement learning is introduced using the formal framework of the Markov Decision Processes. After having shown the existence and uniqueness of a solution in the form of the value function, we will discuss the classical algorithms used to calculate this function. We will then see how approximate methods (linear approximation, monte carlo estimation, bandits, deep learning) can be used to tackle more complex contexts.

Learning outcomes: Understand the theoretical foundations of reinforcement learning. Implement these methods in a way that is adapted to the problems to be solved. Sharpen your critical thinking skills.

Teaching methods: Taking into account the context (group size), lectures will be as interactive as possible andd will aim to present the theoretical and algorithmic concepts underlying reinforcement learning. The purpose of the practical work is to really confront the methods by implementing and testing the algorithms to better understand how they work and their limitations.

Means: Courses and practical work are provided by Alain DUTECH, Hervé FREZZA-BUET and Jérémy FIX. The practical work will be based on the Python language and its scientific libraries.

Evaluation methods: The module will be evaluated by a written exam, where the idea is to test the student's ability to use methods in a clever way, to analyze the results of an algorithm, etc.

Evaluated skills:
- Modelling
- Research and Development

CM:

1. Intro (1.5 h)
2. Prog. Dynamique (1.5 h)
3. Apprentissage par Renforcement (1.5 h)
4. Méthodes approchées (1.5 h)
5. Difficultés classiques (1.5 h)
6. Apprentissage par Renforcement Profond (1.5 h)

TD:

1. Modéliser une Question (3.0 h)

TP:

1. Probl. Académiques (3.0 h)
2. Probl. Continus (3.0 h)
3. App. Renf. Profond (3.0 h)

Advanced databases

Course supervisor: Stéphane Vialle

Total: 23.0 h (optional) **CM:** 9.0 h, **TD:** 3.0 h, **TP:** 6.0 h, **Projet:** 4.5 h

SPM-INF-018 *back*

Evaluation methods: Project report and defense

Evaluated skills:
- Modelling
- System
- Development

CM:

1. Cours d'indexation et d'optimisation d'une BdD relationelle (1.5 h)
2. Cours de principes et d'exemples d'ORM (1.5 h)
3. Cours d'introduction aux BdD NoSQL : émergence et types de bases) (1.5 h)
4. Cours d'introduction aux BdD NoSQL : mécanismes, construction de bases, déploiement) (1.5 h)
5. Cours de présentation de MongoDB (1.5 h)
6. Cours sur la nécessité du nettoyage et de la préparation des données (1.5 h)

TD:

1. TD d'optimisation d'une BdD relationelle (1.5 h)
2. TD de préparation des données en MongoDB (1.5 h)

TP:

1. TP d'optimisation d'une BdD relationelle (3.0 h)
2. TP d'interrogation d'une BdD MongoDB (3.0 h)

Natural language processing

Course supervisor: Joël Legrand

Total: 36.0 h **CM:** 9.0 h, **TP:** 25.0 h

3MD4150 *back*

Description: This course explores the fundamentals of automatic natural language processing (ANNP), covering topics such as word embeddings, language models, recurrent and recursive neural networks and transformers, enabling students to master text analysis and generation.

Content: This course introduces the main linguistic theories used to model natural language (e.g. formal grammars, dependency grammars, etc.). It presents the various natural language processing (NLP) tools available and the statistical models on which they are based. Particular emphasis will be placed on the deep learning methods that constitute the state of the art for most NLP tasks.

Learning outcomes: By the end of this course, participants will have acquired a thorough understanding of the fundamental concepts of NLP. They will be able to apply text preprocessing techniques to clean and organize linguistic data, as well as use pre-trained language models for various tasks such as text classification, text generation, machine translation. Learners will be proficient in the use of popular natural language processing libraries such as NLTK, SpaCy, Transformers.

Teaching methods: Each session will include a lecture part during which new concepts will be introduced, followed by a practical work session. Practical work sessions will be direct applications concepts seen in lectures. All teaching materials will be provided to students.

Evaluation methods: 2h written test, can be retaken.

Evaluated skills:
- Research and Development
- Business Intelligence

CM:

1. Word representations (1.0 h)
2. Language models (1.0 h)
3. Sequence labeling (1.0 h)
4. Sentence classification (1.0 h)
5. Syntactic analysis: constituency parsing (1.0 h)
6. Syntactic analysis and RNN (1.0 h)
7. Machine translation (1.0 h)
8. Machine translations with Seq2seq RNN and attention mechanisms (1.0 h)
9. Le modèle transformer (1.0 h)

TP:

1. Word representations (2.0 h)
2. Word embeddings (2.0 h)
3. Sequence labeling (2.0 h)
4. LSTM (2.0 h)
5. RNN language model (2.0 h)
6. Sentiment analysis with RNN (2.0 h)
7. Machine translation (2.0 h)
8. Machine translations with Seq2seq RNN and attention mechanisms (2.0 h)
9. Le modèle transformer (2.0 h)
10. Fine-tuning de transformers génératifs (4.0 h)

11. Retrieval-augmented generation (RAG) (3.0 h)

Perspectives in Learning and Artificial Intelligence

Course supervisor: Joël Legrand

Total: 23.5 h **CM:** 8.5 h, **TP:** 15.0 h

3MD4110 *back*

Description: This module offers insight into real-world applications of machine learning through talks by researchers and industry professionals. Each session highlights a specific application domain (healthcare, finance, energy, robotics, etc.), illustrating how classical or advanced techniques are used to address real-world problems. These talks complement academic instruction by exposing students to more advanced approaches at times, thereby fostering a broader understanding of current challenges and practices in professional or research settings.

Learning outcomes: At the end of this module, students will have gained a broad perspective on real-world applications of machine learning across various sectors. They will be able to analyze real-world problems through the lens of AI, understand the methodological choices made by experts, and identify the specific constraints related to implementing solutions in industrial or research contexts. This module will also enhance their ability to engage in dialogue with professionals in the field and to envision themselves contributing to interdisciplinary projects involving machine learning.

Means: Each module (5 in total) is given by an industrialist or a researcher. It consists of a 1h30 lecture followed by a 3h practical session.

Evaluation methods: At the end of each practical session, a submission will be required by the instructor. One submission will then be randomly selected for evaluation by the instructor. The grade given will serve as the assessment for the entire module.

Evaluated skills:
- Research and Development
- Development

CM:

1. Introduction (1.0 h)
2. Conférence 1 (1.5 h)
3. Conférence 2 (1.5 h)
4. Conférence 3 (1.5 h)
5. Conférence 4 (1.5 h)
6. Conférence 5 (1.5 h)

TP:

1. TP 1 (3.0 h)
2. TP 2 (3.0 h)
3. TP 3 (3.0 h)
4. TP 4 (3.0 h)
5. TP 5 (3.0 h)

Financial management

Course supervisor: Hervé Frezza-Buet, Damien Rontani

Total: 15.0 h **CM:** 7.5 h, **TD:** 7.5 h

SPM-HEP-007 *back*

Description: This module aims to equip engineering students with the fundamentals of financial management applied to innovative projects and entrepreneurship. Specifically designed for technical profiles involved in the creation or development of startups, it combines a rigorous accounting approach (reading and interpreting the balance sheet, income statement, cash flow statement, cost analysis) with a detailed understanding of innovation-specific financing mechanisms (fundraising, venture capital, grants, cash flow forecasting, company valuation). The course is structured around a continuous case study: a fictional tech startup that students follow through its development, progressively applying financial analysis and management tools. The module pays particular attention to the specifics of tech companies (intangible assets, SaaS KPIs such as CAC or CLV, adapted valuation methods) and also introduces key strategies for managing financial risks. The pedagogy is interactive, with group work, Excel simulations, and oral presentations, preparing students to make informed financial decisions in complex, dynamic, and uncertain environments.

Learning outcomes: By the end of this course, students will be able to interpret financial statements and develop strategies to finance ambitious projects.

Evaluation methods: Multiple-choice exam + case study presentation

Evaluated skills:

- Business Intelligence

CM:

1. Introduction à la gestion financière pour l'innovation (1.0 h)
2. Lecture des états financiers : bilan, compte de résultat, flux de trésorerie (1.0 h)
3. Comptabilité analytique & analyse de rentabilité (1.0 h)
4. Trésorerie et besoin en fonds de roulement (BFR) (1.0 h)
5. Méthodes d'évaluation des startups (1.5 h)
6. Stratégies de financement de l'innovation (1.0 h)
7. Gestion des risques financiers liés à l'innovation (1.0 h)

TD:

1. Analyse d'états financiers simplifiés (2.0 h)
2. Application à la structure de coûts de la startup (1.0 h)
3. Construction d'un plan de trésorerie (1.0 h)
4. Valorisation de la startup fictive (1.5 h)
5. Construction d'une stratégie de financement (1.0 h)
6. Finalisation & restitution de l'étude de cas (1.0 h)

Management

Course supervisor: Damien Rontani, Hervé Frezza-Buet

Total: 19.0 h **TD:** 19.0 h

SPM-HEP-022 *back*

Description: The objective of this course is to help students understand personal and interpersonal dynamics in a professional context, enabling them to manage their careers and projects effectively and humanely.

Evaluated skills:
- Management

TD:

1. tbd (19.0 h)

End-of-studies internship

Course supervisor: Hervé Frezza-Buet, Damien Rontani

SPM-STA-003 *back*

Evaluated skills:

- Modelling
- Research and Development
- Development
- Certification
- System
- Consulting
- Business Intelligence
- Management

Foreign Languages and Culture 1

Course supervisor: Elisabeth Leuba

Total: 11.5 h **TD:** 11.5 h

LV1S10 *back*

Description: The first foreign language is generally English. Students are divided into level groups ; in class, work is not only focused on the 4 language competences but also on various topics studied in depth according to students' levels. Topics cover a range of fields, such as civilisation, society and the professional world. Limited class size enables active participation and significant improvement in the language. The educational approach is varied: group work, class presentations, specific exercises, research, debates, etc.

Learning outcomes: At the end of the course, students will have improved their ability to communicate in an international professional, academic or personal context.

Evaluation methods: Assessment will be by continuous assessment according to criteria to be determined by each teacher, taking into account personal investment in the course. Each course will be marked out of 20 at the end of the semester.

Evaluated skills:
- Research and Development
- Consulting
- Business Intelligence
- Management

TD:

1. Cours (11.5 h)

Foreign Languages and Culture 2

Course supervisor: Beate Mansanti

Total: 11.5 h **TD:** 11.5 h

LV2S10 *back*

Description: Students are offered a range of second foreign languages at different levels, including for beginners. Students are divided into level groups; in class, work is not only focused on the 4 language competences but also on various topics studied in depth according to students' levels. Topics cover a range of fields, such as civilisation, society and the professional world. Limited class size enables active participation and significant improvement in the language. The educational approach is varied: group work, class presentations, specific exercises, research, debates, etc.

Learning outcomes: At the end of the course, students will have improved their ability to communicate in an international professional, academic or personal context.

Evaluation methods: Assessment will be by continuous assessment according to criteria to be determined by each teacher, taking into account personal investment in the course. Each course will be marked out of 20 at the end of the semester.

Evaluated skills:
- Research and Development
- Consulting
- Business Intelligence
- Management

TD:

1. Cours (11.5 h)