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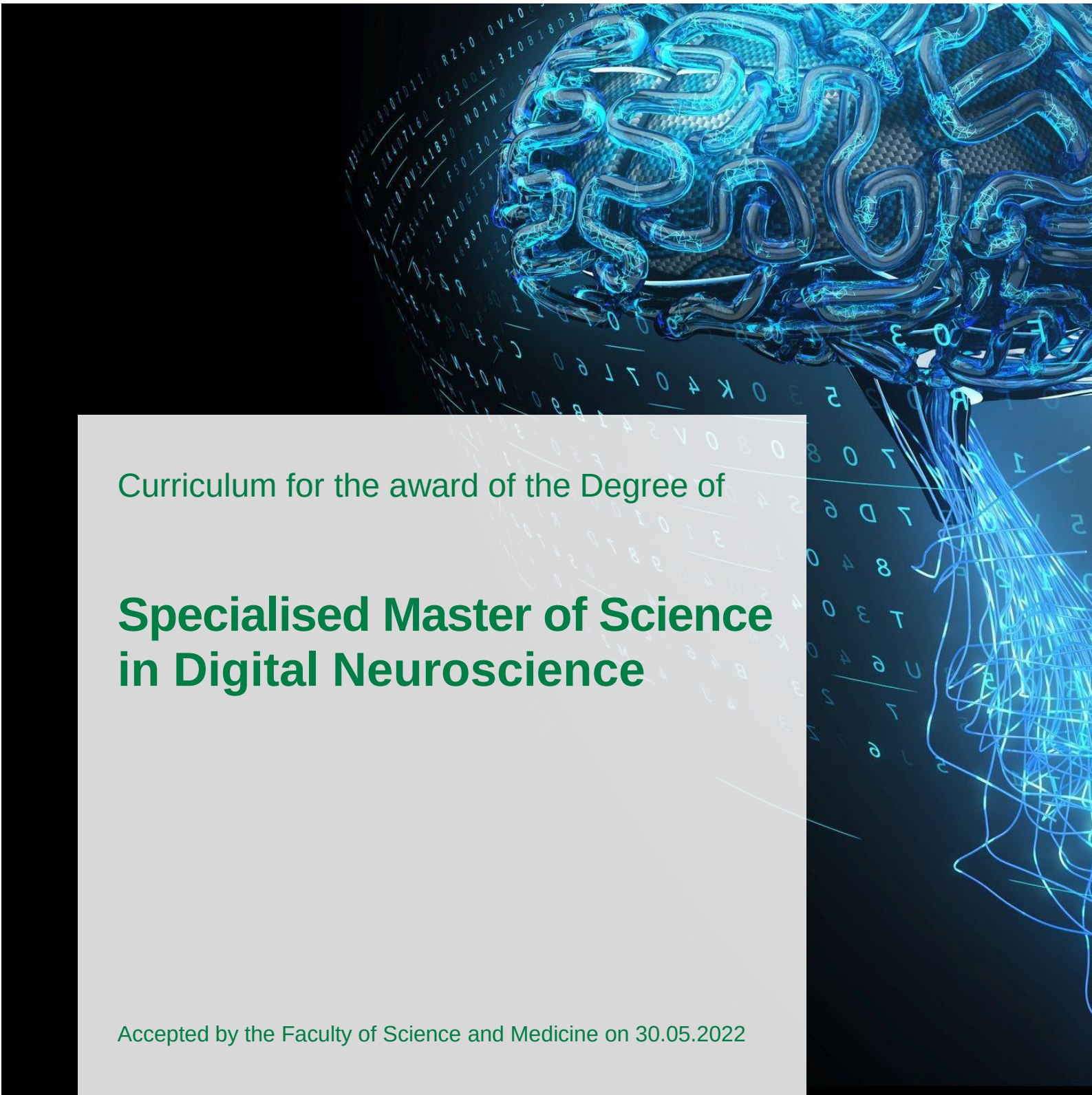

Curriculum for the award of the Degree of

Specialised Master of Science in Digital Neuroscience

Accepted by the Faculty of Science and Medicine on 30.05.2022

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1 General remarks

This curriculum describes all regulations concerning the study of digital neuroscience at the Master level at the University of Fribourg. It is based on the regulations of the Faculty of Science and Medicine as defined in the *Règlement pour l'obtention des Bachelor of Science et des Master of Science de la Faculté des sciences et de médecine*, which entered into force on 30 May 2022 (hereafter called the *Regulation* in short).

The Regulation of 30 May 2022 for the award of the Bachelor of Science and Master of Science degrees establishes a limit on the duration of Bachelor's and Master's studies, as well as of the minor study program (see articles 11, 13 and 14) (https://www.unifr.ch/scimed/fr/rules/regulations).

1.1 Academic title and study plan

The Faculty of Science and Medicine of the University of Fribourg awards the following official academic title to students who have successfully completed their studies: **Specialised Master of Science in Digital Neuroscience (sp-MSc), University of Fribourg**

The **sp-MSc study programme** in Digital Neuroscience (subsequently called sp-MSc) provides the students with advanced courses in the fields of neuroscience, complemented by a broad set of digitalization skills such as data analytics and machine learning, that will equip students to understand and develop neuroscience inspired digital solutions. The programme aims to prepare students for a PhD programme. At the same time, the programme provides students with skills needed for a successful career in health-related industry, data analytics and administration.

Candidates with a Bachelor's degree in Life Sciences (such as Human Medicine, Biomedical Sciences, Biochemistry, Biology, etc.), Psychology, Informatics, Physics, Economics, Engineering or a related subject area, from the University of Fribourg or from another Swiss university, can apply to the sp-MSc (as outlined in Section 2.5 below). Applicants in possession of a BSc degree from other countries or in a different but related subject can also be admitted into the programme based on a decision of the Faculty of Science and Medicine. The admission decision is made individually for each case. Provisional admission can be granted and depends on the fulfilment of additional requirements set by the Faculty (see Section 2.5 below).

1.2 Course structure

The course work leading to the sp-MSc degree is subdivided into "**UE**" (= teaching units, from "unité d'enseignement" or "Unterrichtseinheit"), consisting of formal lectures, exercise classes, practical courses, seminars, and specialised projects. To each UE, a number of **ECTS credits** *(European Credit Transfer System)* is assigned.

The sp-MSc degree requires a minimum of 120 ECTS credits over four semesters. The programme is subdivided into three Validation Packages as follows:

- Compulsory courses (42 ECTS credits) including formal lectures, practical courses, projects, seminars
- Elective courses (18 ECTS credits), including formal lectures, practical courses, projects, seminars
- Master thesis and related activities (60 ECTS credits), including production of the Master thesis, related work and presentation.

The purpose of the different UE types is as follows:

- **Lectures** give a formal introduction to the scientific methods in basic and experimental biomedical research and encourage advanced scientific thinking. They help acquiring the basic knowledge and understanding of the fundamental concepts in specific disciplines.
- **Laboratory work**, be it experimental or theoretical, is the basis of scientific research. It provides a supervised environment for the hands-on realization of biological and medical measurements. It is during this work that the student will encounter and learn many of the techniques and instruments used in biological and medical research.
- **Seminar presentations** are used to expand the student's knowledge in specialised domains, often neglected in the formal courses, as well as to begin the development of oral presentation skills for communication of scientific results.
- **Student projects** are a first step towards applying the skills learned in the lectures and exercise classes to address and solve appropriate research questions.
- The preparation of the **Master thesis**, under the supervision of an experienced researcher, is the actual starting point of scientific research.

1.3 Acquired skills

The aim of the studies leading to the award of an sp-MSc in Digital Neuroscience is to deepen knowledge and techniques, and to perfect competence in the field of Digital Neuroscience, while developing skills in technical English and scientific writing. By the end of the study programme, the students will prove their newly acquired capabilities by completing a research project with their thesis work, learning how to work independently, integrating themselves in an interdisciplinary research team, and present and discuss the obtained results. This programme particularly emphasizes practical computational skills, with the aim of preparing the student not only for a continuation of their academic path, but especially for an accomplished career in an industrial or start-up environment. The successful completion of the degree requires creative and self-critical talents as well as the ability to both communicate ideas and work in English.

1.4 Course assessment (UE) and accreditation of ECTS credits

Acquisition of ECTS credits occurs via three steps: assessment of individual UE, grouping of UE into a validation package, and awarding the respective ECTS credits for the completed package.

Assessment of lectures is made by an oral and/or written exam, whose type and duration are specified in an appendix to this curriculum. Exams occur during the official exam sessions in winter, summer, or autumn, and are subject to a fee. Students register for each exam via the students' web portal MyUniFR (https://my.unifr.ch), within the stipulated deadlines according to the on-line procedure and using their University-provided account and password. The marks range from 6 (highest mark) to 1 (lowest mark). An exam marked below 4 can be repeated, but only once, and at earliest during the next exam session.

A **Validation package** comprises multiple, separately assessed, UE. Article 24 and 27 of the Regulation determines the number of these packages whereas this curriculum determines their content.

The conditions for validation of ECTS credits are described in Art. 25 of the Regulation.

After the validation, upon request, the Dean's office will issue Transcripts of records in which exam results and awarded credits are acknowledged (Art. 28 and 30 of the Regulation), provided the exam fee has been paid.

1.5 Teaching languages

Courses are generally taught in English, although selected courses may be conducted in the German or French language. Written work (project reports, Master thesis, etc.) will preferably be in English. Texts in French or in German can be accepted in selected courses, but only at the lecturer's discretion.

1.6 Ethics and science

Ethical principles are an integral part of a scientific education. Accepted international conventions must be respected during research and while documenting all scientific work whether it be a project, a lecture, a thesis, or a report. In particular, every external source of information (articles, lectures, web pages, etc.) must be correctly cited.

1.7 Regulations and additional Information

Detailed information about studying Digital Neuroscience can be found in the documents referenced on the web page http://www.unifr.ch/scimed/plans as well as from the Office of the Department of Informatics.

2 Specialised Master of Science (sp-MSc)

[Version 2022, validation packages:PV-SNS.000001, PV-SNS.000002, PV-SNS.000003]

The sp-MSc programme in Digital Neuroscience requires 120 ECTS credits to be completed and is expected to take 24 months. The first year consists primarily of courses and seminars, designed to strengthen and complete the student's foundational knowledge in neuroscience and computer science, as well as the proper scientific conduct and skills to communicate research. The second year will broaden the student's education while introducing the preparation of the Master work. As members of a research team, the Master students are expected to take part in various activities such as research group meetings, seminars, and literature study/journal clubs, throughout the duration of the study. The sp-MSc degree course is completed by a research project, which includes the writing of a Master thesis and its successful presentation.

2.1 Teaching units

In the two years of the study programme, sp-MSc students follow a set of compulsory teaching units (Validation Package 1: 42 ECTS), a custom selection of elective courses (Validation Package 2: 18 ECTS), and the Master thesis work (Validation Package 3: 60 ECTS). These aim at providing the student with strong foundations in the fields of Neuroscience and Computer Science oriented towards Data Analytics and Machine Learning, while allowing the students to complete their curriculum towards further breadth or specialisation following their personal career aspirations.

The student is responsible for submitting their selection of elective courses for Validation Package 2 for approval to the Study Advisor. Each selection is evaluated on a per-case basis: for this reason, the selection needs to be submitted at least 2 months before the beginning of each semester, to allow time for validation and potentially iterative corrections.

In principle, all courses issued at any affiliated Swiss university as part of their Master programmes are eligible for selection, though the final decision rests with the Study Advisor. Courses on topics tangential to the core of this programme need to be expressly justified in the written request. The list of *Elective Teaching Units* below (expanded in Section 2.2.2) offers a choice of pre-approved and recommended courses from the University of Fribourg.

***Compulsory** Teaching Units*

Code	Title of UE	Semester	tot. h.	ECTS
SDN.00001	Introduction to neuroscience	AS	28	3
SDN.00002	Foundations of informatics	AS	28	3
SDN.00003	Current topics in digital neuroscience	SS	28	3
I09.00005	Python programming online	SS	28	3
I09.00006	Data analytics in Python	AS	28	3
SDN.00004	Advanced analysis of EEG signals	SS	28	3
SDN.00005	Analysing health data from wearable biosensors	SS	28	3
SME.07502	Advanced scientific writing	SS	28	3
SME.07700	Data analysis and statistics with the R programming language	AS	28	3
SIN.08022	Machine learning	SS	56	5
SIN.08609	Social media analytics	SS	42	5
SIN.08612	Multimodal user interfaces	SS	42	5
Total				**42**

Students already qualified in these domains can request to take extra Elective courses for the same ECTS instead in agreement with the study advisor. These will be part of the Compulsory validation package

***Elective** teaching Units*

Code	Title of UE	Semester	tot. h.	ECTS
SME.07300	Central nervous system regeneration and repair	AS	28	3
SME.07301	Behavioural methods in neuroscience	AS	28	3
SME.07501	Scientific communication	AS	28	3
L25.00715*	Neuroethics	SS	28	3
L25.00644*	Introduction to Matlab I	AS	28	3
SIN.01022	Computer architecture	AS	56	5
SIN.07504	User centered design	AS	42	5
SIN.08608	Pattern recognition	SS	56	5
-**	Distributed algorithms	SS	56	5
-**	Big data infrastructures	AS	56	5
Total	**(Selected courses only)**			**18**

* Offered by the Dept. of Psychology, Faculty of Humanities
** Offered by the University of Bern

Elective courses listed above are pre-approved and recommended for the student's courses selections. Students can and are encouraged to include courses outside of this list, from both the University of Fribourg and other Swiss universities. Their proposed list however is strictly subject to a case-by-case validation and approval by the Study Advisor, prior to the student beginning to take the courses.

Students are required to obtain a minimum of 18 ECTS for this Validation Package. The maximum allowed is 26 ECTS: any additional ECTS credits can be chosen as additional studies, but will not count in the grade point average (Art. 24).

The list of pre-approved Elective courses is subject to change: please find the up-to-date list on Moodle.

***Master thesis** Work*

Code	Title of UE	Semester	tot. h.	ECTS
SDN.00010	Master thesis and presentation	AS/SS		58
SDN.00011	Master thesis-related activities	AS/SS		2
Total				**60**

2.2 Content of the teaching units

2.2.1 Compulsory teaching units

The course *Introduction to neuroscience* (SDN.00001) covers the basic concepts of neuroscience, from how neurons communicate to brain anatomy and function, and how brain function arises from computations accomplished by the brain. In this interactive course, students will be presented with selected topics from cognitive, computational and systems neuroscience, encompassing brain evolution, organization, neuronal computation and the organization of cognitive systems. Students will learn to discuss fundamental questions in neuroscience, learning to critically think about brain function.

The course *Foundations of informatics* (SDN.00002) aims at providing the student with some of the fundamental topics to best understand and utilize digital tools. The main topics include computer and network architecture, classical logics, Boolean operators, algorithm design, data structures, and information theory. Students from all backgrounds will receive the foundations for

a proficient utilization of computational resources, particularly with a focus towards data processing and analysis.

The course *Current topics in neuroscience* (SDN.00003) introduces the students to the neuroscience research projects currently pursued at the University of Fribourg and affiliated institutions. Individual group leaders will introduce their research topics and methodology in the domains of systems and cognitive neuroscience. Specific topics include sleep and mental health, attention and learning, and approaches in neurorehabilitation. Students will explore how state-of-the-art computational methods such as machine learning are being integrated in the research process, and how to further the approach into real-world applications.

The course *Python programming online* (I09.00005) will present the students with the fundamental skills necessary to achieve proficiency in the Python programming language, without any prior knowledge as a prerequisite. The goal is to empower students of all disciplines and levels to create small software applications and data analyses. The course is provided online in the form of videos and exercises that need to be accomplished by the participants. The frontal lectures focus on helping the students with regular exercises.

The course *Data analytics in Python* (I09.00006) aims at familiarizing the students with data analysis processes using the Python programming language. This is done by pursuing three objectives in parallel. First, the students are exposed to fundamental and advanced tools in Python, improving the technical skillset of the students and their ability to express problem and solutions in a programming language. Second is data preparation, including handling heterogeneous data types and mitigating issues in the data such as noise and missing values. Third, the students will learn to access, customize and improve standard machine learning techniques for data handling such as regression and support vector machines, together with the proper tools for visual analysis and performance reporting.

The course *Advanced analysis of EEG signals* (SDN.00004) will present state-of-the-art computational non-invasive electrophysiological data analysis methods and their application in research. The students will learn how those brain signals are generated and recorded from the brain, as well as their functional interpretation. They will then gain experience in programming using specific toolboxes that have been developed to extract the neuro-functional signatures from continuous EEG signals. This class should provide students with the theoretical concepts and methodological bases to use any of the wide range of computational tools available in the field. To this aim, the students will have theoretical and practical hands-on sessions to develop code to analyse EEG data.

The course *Analysing health data from wearable biosensors* (SDN.00005) provides an overview of recent advances and developments in wearable sensors and their application for health-related data acquisition. The course will include theoretical and physiological background information, data examples and analytical tools on selected signals including e.g. motor activity, heart rate, skin temperature and other biological and chemical signals. Emphasis will be put on data analysis and (automated) data interpretation for the user and researcher and its potential and limitations, especially with respect to the particularities of physiological data acquired in a real-world context (noise, longitudinal data structure etc.).

The course *Data analysis and statistics with the R programming language* (SME.07700) consists of two parts. The first part is an introduction to the R programming language. The second part of the course focuses on experimental design and statistical analysis, addressing the underlying concepts and presenting the main parametric and non-parametric tests used in inferential statistics.

The course *Social media analytics* (SIN.08609) will cover techniques and algorithms to analyse the structure of large social networks, and to identify their main properties. It starts by introducing the basic concepts of social media analytics, then delve into the main measures and models used for social media networks, and the techniques applied to identify communities. Finally, the course

covers social media applications including diffusion/influence in social networks, crowdsourcing on the web, social recommendation and location-based social media.

The course *Multimodal user interfaces* (SIN.08612) studies the coordination of natural input modalities (such as voice, gesture, facial expressions etc.) with multimedia output modalities (such as video, audio, information visualizations, 3D graphics etc.). This course will provide the students with the basic techniques for designing, implementing and evaluating multimodal interfaces, as well as theoretical knowledge on multimodality, representation, visualization of information and cognitive ergonomics.

The course *Machine learning* (SIN.08022) aims at understanding the foundation of Machine Learning as a field, providing the basis to master its many branches and applications. After an introduction about how machines learn, the focus will be on a short selection of key algorithms for supervised, unsupervised and reinforcement learning. The students will learn how parametrised function approximators can be used to take decisions, how to update their parametrisation to modify their behaviour, and how to leverage data and interactions in real-world applications.

The course *Advanced scientific writing* (SME.07502) encompasses literature research, reading, writing, reviewing, editing and publishing. It engages students in a real-world exercise of scientific writing and publishing. The students will gain experience in scientific writing through an individual essay (scientific review article or book chapter)**.** This will increase the students' skills in word processing and reference management systems. The students will participate in critical evaluation of scientific writing by assessing peer-written work**,** explore relevant web sites and become familiar with electronic publishing.

2.2.2 Elective teaching units

The following is a brief description of the courses pre-approved for student selection in the context of the Elective Teaching Units. It remains the responsibility of each student to propose a coherent selection of courses, in writing, to the Study Advisor at least two months before the start of the relevant semester, which will be subject to a per-case approval.

The course *Central nervous system regeneration and repair* (SME.07300) provides the conceptual background necessary for understanding major approaches for helping the brain recover from neural pathologies. The importance of behavioural characterization, functional measurements as well as therapeutic interventions such as psychopharmacology or electrical brain stimulation is illustrated by relevant examples drawn from clinical and basic science.

The course *Behavioural methods in neuroscience* (SME.07301) introduces participants to laboratory methods used for behavioural and associated functional studies in humans and animals. The focus lies on measurement, analysis and interpretation of behavioural parameters such as behavioural choice or reaction time, as well as functional parameters such as electroencephalographic recordings. The course is conducted in 7 modules lasting four hours each and takes place in specialised laboratories.

The course *Scientific communication* (SME.07501) provides a review of the principles and practice of the various forms of scientific communication, which is an integral part of research activity. Its objective is to learn how to communicate scientific results accurately, ending by a mini-symposium with presentations made by the students.

The course *Neuroethics* (L25.00715) introduces the basic concepts of neuroethics and discusses some of the most intriguing and pressing ethical questions in the neurosciences, such as cognitive enhancement and brain stimulation, brain imaging and 'mind reading', mood enhancement and self-optimization, dual use and misconduct potential, as well as the responsibility of neuroscientists. In addition, the course will discuss how our understanding of the neuronal basis of the mind shapes our view of ourselves as well as of other animals.

The course *Introduction to Matlab I* (L25.0064) This course presents the basics of programming in Matlab. Students will first be introduced to the interface of Matlab, they will then learn how to initiate variables and how to do some basic calculations, moreover we will introduce how to generate vectors/matrices/tables/cells/structures and how to retrieve information from these objects; we will also show the most common functions included in Matlab: (for loops, while loops, if and else, switch case). Finally, we will present how to import/write/save and load data and results. In summary, this course will offer the students the ability to preprocess their own data and to do some basic analysis.

The course *Computer architecture* (SIN.01022) allows the study of the operating principle of computers: the representation of information (numerical and non-numerical), combinatorial and sequential logic systems, the operation of the basic elements of a computer (processors, memories) and the machine language. It provides an extensive introduction to Computer Science as a field that can be followed by students of different background with minimal prior knowledge.

The course *User centered design* (SIN.07504) present User-Centred Design (UCD) processes and methodologies. UCD provide methods to put in light the needs, wants, and limitations of end users of an interface at each stage of the design process. Further, UCD provides methods to support and evaluate early designs, low fidelity prototypes and products. In addition to design support and user requirements analysis, the class will present usability engineering methods to evaluate the performance and efficiency of a given user interface, as well as statistical methods to conclude on the significance of the results. All along the class, students will apply the methodologies learned on the design and prototyping of an interactive product.

The course *Pattern recognition* (SIN.08608) studies the fundaments of pattern recognition from an engineering point of view. The core methods and algorithms are elaborated that enable pattern recognition for a wide range of data sources including sensory data (image, video, audio, location, etc.) as well as born-digital data (text, network traffic, chemical formulas, etc.). Topics include standard methods for unsupervised clustering and supervised classification in vector spaces, structural pattern recognition based on string and graph representation, and clustering and classification of structural data using dissimilarity and vector space embeddings. The course is accompanied by practical exercises that involve the implementation of algorithms discussed in class and their application to exemplary pattern recognition tasks.

The course *Distributed algorithms* introduces computing in a distributed environment without a central coordinator. It presents fundamental programming abstractions for distributed systems and fault-tolerant, highly available, and secure protocols that implement them. Topics include replication, quorums, reliable broadcast, distributed storage, consensus, Byzantine agreement, atomic broadcast, and notions of consistency arising in this setting. Applications to real-world systems will be presented, in the domain of cloud computing, cryptocurrencies, and blockchain systems.

The course *Big data infrastructures* focuses on conceptual and architectural issues related to the design and deployment of modern data management infrastructures in a Big Data context. It starts with a review of distributed transaction processing techniques, classical parallel databases systems and ACID-style semantics in shared-nothing architectures. The course then delves into modern wide-area data processing, with an emphasis on recent systems developed to solve large-scale problems using clusters of commodity machines.

2.3 Exams and assessment

Assessment criteria for UEs are specified in the appendices to the curriculum in Digital Neuroscience (units with codes SDN), Informatics (units with codes SIN), Medical Sciences (units with code SME) respectively. Assessment modalities for courses taught by other faculties or universities are to be found in their curricula or websites. The UEs of the Master's *Compulsory*

courses are assessed in the first validation package and awards the student 42 ECTS credits if successful, while the Master's *Elective courses* are assessed in the second validation package and awards the student 18 ECTS credits if successful. See Section 2.4 below for details regarding the third Validation Package.

2.4 Master thesis and exam

The third validation package of the Master's programme corresponds to the Master thesis work and account for 60 ECTS credits. It consists of two UEs dedicated to the *Master thesis* (SDN.00010, 58 ECTS) and to the *Master thesis-related activities* (SDN.00011, 2 ECTS). This work is foreseen to be completed within 12 months. The student will collaborate directly with a specific laboratory or affiliated company, and focus on research, with the objective of developing the student's aptitude for fundamental, neuroscience and/or computer science research. In order to collaborate with a laboratory outside the University of Fribourg, or in all cases for collaborations involving external companies, the student needs to submit a written request and receive explicit approval (on a per-case basis) from the Study Advisor before the start of the work.

In any case, the student will carry out the thesis work under the supervision of an active researcher in the field affiliated with the University of Fribourg. The work will be presented both as a formal written document, and as a 30-minute oral presentation, and evaluated on the same grade scale as the exams. If a work is judged insufficient, a second Master thesis project may be offered to the student.

Successful completion of all three validation packages results in the right to the title: **Specialised Master of Science in Digital Neuroscience**, **University of Fribourg (sp-MSc)**.

2.5 Admission regulations for the Master's programme

To be admitted to the Master's programme, students must fulfil the University admission requirements, as defined in the *Règlement concernant l'admission à l'Université de Fribourg* (https://www.unifr.ch/apps/legal/fr/document/274904).

The number of students accepted is limited to the training capacities of the Department NMS (Neuroscience and Movement Sciences), Department MPH (Community Health, Psychiatry), Department of Informatics and Department of Psychology. Candidates should submit a complete application that includes the following documents:

- Bachelor's degree diploma in an approved subject area (see Section 1.1; original or certified copy).
- Transcript of records.
- Description of their Bachelor's studies (for applicants coming from Universities other than Fribourg), including information about the content and volume of the courses.
- Motivation letter.
- One or two letter(s) of recommendation from an academic professional. The referee should specify in which capacity they have formed an expert opinion of the applicant.

The applications will be evaluated, and selected candidates may be invited for an interview by the Study Advisor when deemed necessary. The selection criteria for the evaluation are the academic performance during previous academic studies, the motivation for pursuit of studies in the Master's programme, and the content of the recommendation letter(s).