LLUI

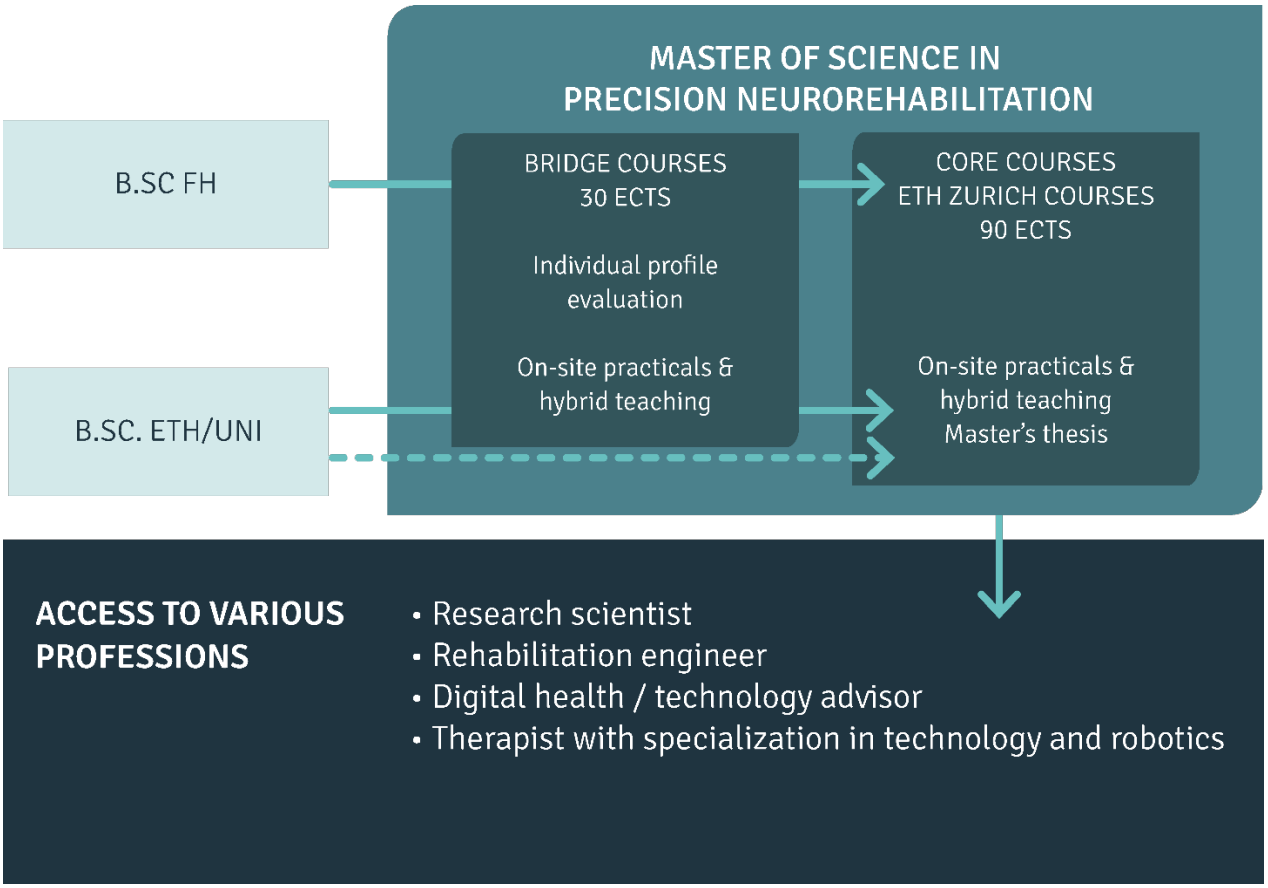
www.llui.org/education

MASTER OF SCIENCE
PRECISION NEUROREHABILITATION (PNR)

PNR Course Handbook, V3.0

PRECISION NEUROREHABILITATION MASTER

The master's program uniquely equips students with comprehensive knowledge and practical skills, positioning them at the forefront of healthcare and technology advancements.



OUR STUDENTS WILL...

- Gain in-depth expertise in concepts and methodologies in neurorehabilitation, engineering and applied movement science. Learn to use this expertise to effectively implement a technology-driven approach to precision neurorehabilitation.
- Acquire the competence to critically analyze and evaluate evidence-based practices and scientific findings, fostering a reflective and informed approach to professional decision-making.
- Acquire communication and professional skills to lead teams in a variety of healthcare settings and across the neurorehabilitation industry.

COURSE OVERVIEW PART-TIME STUDIES

FALL SEMESTER 1 – 19 ECTS

PNR-P101 1 ECTS
DESIGN THINKING 1

PNR-P202 4 ECTS
SCIENTIFIC METHODS AND LOGICAL THINKING

PNR-P203 5 ECTS
INTRODUCTION TO PROGRAMMING

PNR-P301 4 ECTS
INTRODUCTION TO NEUROSCIENCE

PNR-P104 3 ECTS
MATHEMATICS FOR MOVEMENT ANALYSIS

PNR-P401 1 ECTS
SPOTLIGHT SERIES 1

SPRING SEMESTER 2 – 18 ECTS

PNR-P302 3 ECTS
NEUROANATOMY AND NEUROVASCULAR SYSTEM

PNR-P102 4 ECTS
UNDERSTANDING MECHANICS FOR HUMAN MOVEMENT

PNR-P103 4 ECTS
INTRODUCTION TO MECHATRONICS

PNR-M121 1 ECTS
DESIGN THINKING 2

PNR-M221 3 ECTS
INTRODUCTION TO DATA SCIENCE

PNR-M321 2 ECTS
NEUROPSYCHOLOGY, MOTIVATION & PSYCHIATRY

PNR-M421 1 ECTS
SPOTLIGHT SERIES 2

FALL SEMESTER 3 -18 ECTS

PNR-M121 2 ECTS
DESIGN THINKING 3

PNR-M122 4 ECTS
QUANTIFYING HUMAN PHYSIOLOGY: TECHNOLOGIES AND TECHNIQUES

PNR-M123 4 ECTS
FROM BIOMECHANICS TO MOVEMENT ANALYSIS

PNR-M223 3 ECTS
ADVANCED DATA SCIENCE

PNR-M222 2 ECTS
AI4HEALTHCARE

PNR-M423 1 ECTS
SPOTLIGHT SERIES 3

PNR-M322 2 ECTS
KEY PATHOLOGIES OF NEUROLOGICAL DISORDERS

SPRING SEMESTER 4 – 20 ECTS

PNR-EXTERNAL-131 4 ECTS
REHABILITATION ENGINEERING I
ETH zürich

PNR-EXTERNAL-135 3 ECTS
TRANSFER OF TECHNOLOGIES INTO NEUROREHABILITATION
ETH zürich

PNR-EXTERNAL-431 3 ECTS
TRANSLATION OF CLINICAL CONCEPTS INTO TELEREHABILITATION
ETH zürich

PNR-EXTERNAL-331 4 ECTS
NEURAL CONTROL OF MOVEMENT AND MOTOR LEARNING
ETH zürich

PNR-EXTERNAL-134 6 ECTS
ASSISTIVE TECHNOLOGY CHALLENGE
ETH zürich

FALL SEMESTER 5 – 20 ECTS

PNR-EXTERNAL-332 3 ECTS
MOTOR NEUROREHABILITATION
ETH zürich

PNR-EXTERNAL-132 3 ECTS
REHABILITATION ENGINEERING II
ETH zürich

PNR-E432 1 ECTS
*GOOD CLINICAL PRACTICE***

PNR-M323 2 ECTS
NEUROREHABILITATION PATHWAYS

PNR-M921 6 ECTS
SEMESTER PROJECT*

PNR-M922 30 ECTS
MASTER'S THESIS*

SPRING SEMESTER 6 - 25 ECTS

PNR-M922 30 ECTS
MASTER'S THESIS*

*FLEXIBLE START FOR SEMESTER PROJECT AND MASTER'S THESIS
** ONLINE SELF-STUDY COURSE

BRIDGE COURSE UNITS LLUI | CORE COURSE UNITS LLUI | EXTERNAL COURSE UNITS ETH ZURICH | STUDENT PROJECTS

ABSTRACTS
BRIDGE COURSE UNITS

PNR-P101
DESIGN THINKING 1

ECTS: 1
Semester: Fall Semester 1

Lecturers: Dr. J. Duarte, M. Mokni, Dr. J. Meyer

Summary: This course will introduce students to the general principles of design thinking, a unique approach to problem solving and innovation. We will explore how to understand the user's needs using concepts of user-centric design, how to define a problem effectively, how to generate ideas, and how to iteratively and rapidly prototype and test possible solutions. Through project-based activities, students will learn how to apply these principles to their professional lives. Finally, students will be introduced to methods to quantitatively and qualitatively gather requirements for a technological solution for neurorehabilitation.

PNR-P202
SCIENTIFIC METHODS AND LOGICAL THINKING

ECTS: 4
Semester: Fall Semester 1

Lecturers: Dr. C. Maher, F. Piluso, V. Diehl

Summary: This course offers a comprehensive introduction to the fundamental principles of scientific methods and literature research within the context of Precision Neurorehabilitation. Students will gain insights into the process of scientific inquiry, contemporary practices and methodologies, and the essential tools required for conducting clinical research. Our focus includes critical assessment of scientific procedures, understanding levels of evidence, formulating and executing research questions, exploring study designs, and structuring scientific communications. Additionally, we address ethical considerations and introduce practical research tools such as literature databases, referencing software and artificial intelligence-powered resources.

PNR-P203
INTRODUCTION TO PROGRAMMING

ECTS: 5
Semester: Fall Semester 1

Lecturers: L. Nastasi, Dr. J. Zimmermann

Summary: This course is designed for health care professionals with no programming background. It covers programming fundamentals, including data types, control structures, and debugging, plus clinical problem-solving with algorithms to simplify patient care. Students will gain core programming skills, understand patient data management, and develop automated healthcare solutions. The curriculum emphasizes practical applications in healthcare, from managing patient records to using programming supporting effective treatment solutions. The aim is to empower health professionals with programming skills for healthcare innovations.

PNR-P301
INTRODUCTION TO NEUROSCIENCE

ECTS: 4
Semester: Fall Semester 1

Lecturers: Dr. C. Vitrac, Dr. med. T. Popa, Dr. S. Giovanoli, Dr. M. Widmer

Summary: This course provides an introduction to the cellular, structural, and network principles underlying neural function. Students learn the roles of neurons, glia, and astrocytes in synaptic communication and support, and gain insight into electrical and chemical signaling within neural circuits. Core mechanisms of structural and functional plasticity are explored, including synaptic strengthening, spine dynamics, and conditions that enable learning and long-term adaptation. The course also introduces the anatomical organization of the nervous system and its functional components, linking cellular elements to distributed networks and behavior. Emphasis is placed on how coordinated activity across cells and cooperation between brain regions give rise to behavior and inform our understanding of pathology. This course establishes a fundamental framework for advanced study of neuroanatomy, neural damage, and neurorehabilitation.

PNR-P104

MATHEMATICS FOR MOVEMENT ANALYSIS

ECTS: 3
Semester: Fall Semester 1

Lecturers: Dr. J. Duarte

Summary: This course will give students the mathematical tools needed to understand and describe movement. We will review concepts from basic algebra, calculus, and mathematical functions needed to analyze and interpret human and mechanical motion. Students will work through real-world examples to learn how to apply mathematical tools to quantify and describe motion. This course will be closely linked with the mechanics for movement analysis where the mathematical tools will be applied.

PNR-P102

MOVEMENT FUNDAMENTALS: UNDERSTANDING MECHANICS FOR HUMAN MOVEMENT

ECTS: 4
Semester: Spring Semester 2

Lecturers: Dr. J. Duarte, T. Unger

Summary: This course will introduce students to the general principles of movement (kinematics) and the forces that cause or change motion (kinetics). We will use examples from human movement and biomechanics to study how a person's movements and forces generated by muscles, or applied by external objects, influence its motion. This course will emphasize real-world applications that students may encounter in their professional environments of neurorehabilitation such as orthotic devices and systems used while training a patient.

PNR-P103

INTRODUCTION TO MECHATRONICS

ECTS: 4
Semester: Spring Semester 2

Lecturers: Dr. J. Duarte, M. Mokni

Summary: This course is designed to introduce students to the key principles to design and build robotic devices with emphasis on technology used for neurorehabilitation. We will explore concepts of sensors and actuators, electronic circuits, and how to combine these with mechanical elements to create a robotic device. Through hands-on experience, students will be able to create simple circuits, 3D print mechanical structures, and combine these with sensors and actuators to create intelligent robotic devices for neurorehabilitation.

PNR-P302

NEUROANATOMY, NEUROVASCULAR SYSTEMS, AND PRINCIPLES OF NEURONAL DAMAGE

ECTS: 3
Semester: Spring Semester 2

Lecturers: Dr. med. T. Popa, Dr. S. Giovanoli

Summary: This course deepens students' understanding of the structural and vascular organization of the central nervous system and its relation to function and pathology. Students explore detailed neuroanatomy of the brain and spinal cord, major pathways, nuclei, and network connectivity, alongside the organization of cerebral and spinal blood supply and vascular territories. The course links vascular and structural anatomy to neuronal damage, including ischemia, hemorrhage, trauma, and inflammation, and examines how these disruptions affect circuits and behavior. Through case-based examples, students learn to interpret lesion–symptom relationships, providing a foundation for understanding key pathologies in neurorehabilitation

PNR-P401, M421

SPOTLIGHT SERIES 1-3

ECTS: 3 x 1
Semester: Fall Semester 1, Spring Semester 2, Fall Semester 3

Lecturers: Prof. A. Luft, Prof. G. Hasler, Prof. P. Gasparini, Guest Lecturers

Summary: In this Series, students will have the chance to visit regular spotlight lectures in an interdisciplinary clinical and research environment. Each Spotlight is a self-contained event with at least one expert presentation on a topic from diverse fields, all highly relevant for neurorehabilitation. Students will have the chance to actively participate in a critical scientific discussion. Through the interdisciplinary setup, students will acquire the skills for successful communication among clinicians, researchers, and industry partners.

CORE COURSE UNITS

PNR-M121
DESIGN THINKING 2 & 3

ECTS: 3
Semester: Spring Semester 2

Lecturers: Dr. J. Duarte, M. Mokni, M. Serrano

Summary: These course units are the second and third part of a three-course series that will introduce students to the general principles of design thinking, a unique approach to problem solving and innovation. We will explore how to understand user's needs using concepts of user-centric design, how to define a problem effectively, how to generate ideas, and how to iteratively and rapidly prototype and test possible solutions. Through project-based activities, students will learn how to apply these principles to their professional lives.

PNR-M221
INTRODUCTION TO DATA SCIENCE

ECTS: 3
Semester: Spring Semester 2

Lecturers: Dr. J. Zimmermann

Summary: This course will equip students with essential skills for understanding and analyzing clinical data. Through engaging lectures and interactive sessions, students will explore diverse data types and methodologies for investigating correlations and group differences. Practical applications and hands-on exercises using Python will enable students to develop proficiency in data processing, visualization, and statistical analysis. Emphasis will be placed on fostering interpretation and critical thinking in evaluating clinical data. Additionally, students will develop the ability to translate research questions into testable hypotheses. By the end of the course, students will be able to interpret results and assess statistical accuracy in clinical research articles

PNR-M321
NEUROPSYCHOLOGY, MOTIVATION AND PSYCHIATRY

ECTS: 2
Semester: Spring Semester 2

Lecturers: Dr. L. Legrand, Prof. G. Hasler, Prof. P. Brugger, Prof. A. Serino

Summary: This course is designed to help students understand and proficiently discern the influence of cognitive, motivational, and psychiatric parameters on motor neurorehabilitation. Students acquire knowledge in cognitive neuroscience and neuropsychology to understand the different cognitive functions and how they contribute to motor output, body perception, and motor rehabilitation. From neuroscience of motivation to motivational psychology, students learn how motivational processes can be harnessed to foster successful rehabilitation in traditional and gamified settings. Students are familiarized with psychiatric disorders. They are educated about affective and motor symptoms in psychiatric disease as well as drug-based effects either enhancing or impairing motor performance and rehabilitation.

PNR-M122

QUANTIFYING HUMAN PHYSIOLOGY: TECHNOLOGIES AND TECHNIQUES

ECTS: 4
Semester: Fall Semester 3

Lecturers: Dr. R. Kuster, Dr. M. Bannwart, Dr. B. de las Heras

Summary: This course will cover the topic of the role that physiological parameters play in informing medical personnel and patients about the patient's health status and on the possible paths to improve the patient's health status. Before measuring physiological parameters, it is important to understand how the underlying physiological principles can be reliably measured using biomedical sensors. This course provides the fundamental knowledge behind the physics, methods, and systems that are currently used to measure some of the most relevant physiological parameters for neurorehabilitation. These include electrocardiograph (ECG), electroencephalography (EEG), electromyography (EMG), imaging (x-rays, CT scans, MRI, ultrasound), photoplethysmography (PPG), respiratory, and motion sensors. The technology available to measure the underlying physiological parameters will be presented and critically discussed. Students will gain the understanding needed to select specific systems and signal processing steps for different healthcare applications, making them aware of the limits of the adopted measurement systems.

PNR-M123

FROM BIOMECHANICS TO MOVEMENT ANALYSIS

ECTS: 4
Semester: Fall Semester 3

Lecturers: Ass. Prof. C. Bauer, M. Mokni, S. Neumann

This comprehensive course is structured in three engaging parts: 1) Theory and Foundations: In an interactive lecture attendees will explore the core principles of movement analysis, supported by real-world examples. Key biomechanical concepts are revisited to solidify understanding, enabling participants to grasp essential terminologies and deepen their knowledge through curated online resources. 2) Hands-On Practical Experience: Through practical sessions in state-of-the-art movement labs and with portable devices like accelerometers, participants will gain firsthand experience in applying movement analysis techniques across various settings. 3) Collaborative Project: In small groups, attendees will design, execute, and evaluate their own measurement protocols, putting theory into action and honing their analytical skills.

PNR-M223

ADVANCED DATA SCIENCE

ECTS: 3
Semester: Fall Semester 3

Lecturers: Dr. J. Zimmermann

Summary: This course provides students with the skills needed to comprehend and apply advanced machine learning techniques to clinical data. Students will delve into various topics covering classification, clustering, and deep learning. Through hands-on Python exercises, students will gain practical experiences building clinical prediction models with real-world data. Students will also learn to address current challenges in machine learning, such as explainability and biases. By the end of the course, students will possess the capability to extract valuable insights from complex clinical data using advanced data science methods, empowering them to contribute significantly to advancements in healthcare and medicine.

PNR-M222

AI4HEALTHCARE

ECTS: 2
Semester: Fall Semester 3

Lecturers: Dr. C. Awai

Summary: In this course, students will explore the representation of patients using data, a concept known as a digital twin. We will address questions like: How can we build explainable and trustworthy models? How can we build trust between stakeholders? How can we implement high quality data in clinical routine? Students will follow an example patient in her journey through disease stages and her interactions with medical services. In each stage, we will discuss relevant data recording, data reporting, data transactions, laws/policies, and technologies. After each theoretical input, students will program code snippets to address a specific need to create a digital twin. Finally, we will create an example digital twin, employing knowledge from previous courses in programming and data science.

PNR-M322

KEY PATHOLOGIES OF NEUROLOGICAL DISORDERS

ECTS: 2
Semester: Fall Semester 3

Lecturers: Dr. T. Popa, Prof. A. Luft

Summary: This course will expand upon students' foundational neuroscientific knowledge. It will provide detailed exploration of the various diseases that require neurorehabilitation, focusing on their neurophysiological underpinnings and neuropathological characteristics. Using patient case studies, students will develop the skills needed to use tools for assessments, and using these assessments develop personalized care protocols to meet the individual need of a patient.

PNR-M323

NEUROREHABILITATION PATHWAYS

ECTS: 2
Semester: Fall Semester 5

Lecturers: Prof. A. Luft

Summary: This course delves into the integral role of nursing, speech therapy, language therapy, swallowing therapy, and nutrition in enhancing patient outcomes beyond the restoration of motor function. Through interactive sessions and case studies, students will explore the multidisciplinary approach required for effective neurorehabilitation, emphasizing collaborative efforts between therapists, nurses, and other healthcare professionals. This course will equip students with essential knowledge and skills in holistic patient assessment and care planning, preparing them to deliver comprehensive and personalized support to individuals undergoing neurorehabilitation.

PNR-E432

GOOD CLINICAL PRACTICE

ECTS: 1
Semester: not specified, self-paced learning

Lecturers: Online course

Summary: The Good Clinical Practice (GCP) course covers essential basic knowledge in research ethics. Module 1 of the self-learning platform offered at the Training and Resources in Research Ethics Evaluation (TRREE) platform introduces students to the fundamentals of GCP. It covers the ethical principles governing clinical research, the history and evolution of GCP, and the roles and responsibilities of various stakeholders involved in clinical trials. Module 2 delves into the regulatory framework surrounding clinical research, emphasizing international guidelines and standards. It also explores the importance of obtaining informed consent from participants and the principles of data protection and confidentiality.

PNR-M921

SEMESTER PROJECT

ECTS: 6
Semester: Fall Semester 5

Summary: The semester project incorporates principles of design thinking into real-world clinical applications. The project will be conducted under the supervision of a research scientist who will guide the student through the management of research projects and clinical processes used in neurorehabilitation. Students will gain hands-on experience into the formulation of research questions, planning of experiments, gathering and analysis of data, and the formulation of conclusions based on the experimental results. The semester project is design to prepare students for their Master's thesis.

PNR-M922

MASTER'S THESIS

ECTS: 30
Semester: Spring Semester 6

Summary: A master's thesis will demonstrate the student's ability to conduct independent research, analyze data, and contribute original insights to the field of precision neurorehabilitation. The thesis will be the culmination of the knowledge and skills acquired throughout the program and should reflect critical thinking, analytical rigor, and academic integrity. The thesis can be conducted in close collaboration with clinical practice during a time period of 6 months under the supervision of a research scientist and is evaluated by a committee of faculty members and an external expert. The students will undergo a final presentation and examination, during which they will defend their research findings and methodology to the panel, showcasing their ability to communicate their research process, address questions, and defend their conclusions.

ABSTRACTS
EXTERNAL COURSE UNITS

The LLUI PNR program includes external courses on advanced topics in neurorehabilitation, covering engineering design, biomechanical analysis, and data science models. These courses are held at ETH Zurich and foster interdisciplinary collaboration by connecting students with engineering professionals and peers. PNR students are enrolled as **guests at ETH Zurich**, with **LLUI managing exams and awarding ECTS credits.**

PNR-E431

TRANSLATION OF CLINICAL CONCEPTS INTO TELEREHABILITATION

ECTS: 3
Semester: Fall Semester 4

Lecturers: Dr. C. Awai

Summary: This course provides an in-depth view on the future of (neuro)rehabilitation with a strong focus on place-independent rehabilitation strategies and behavioral adaptations. Current clinical concepts will be introduced and their translation into telerehabilitation investigated.

Source: https://www.vvz.ethz.ch
376-1227-00L Translation of Clinical Concepts into Telerehabilitation

---

PNR-E131

REHABILITATION ENGINEERING I: MOTOR FUNCTIONS

ECTS: 4
Semester: Spring Semester 4

Lecturers: Prof. R. Riener, Dr. C. Awai

Summary: The goal of this course is to present classical and new technical principles as well as specific examples applied to compensate or enhance motor deficits. In the 1 h exercise the students will learn how to solve representative problems with computational methods applied to exoprosthetics, wheelchair dynamics, rehabilitation robotics and neuroprosthetics.

Source: https://www.vvz.ethz.ch
376-1217-00L Rehabilitation Engineering I: Motor Functions

PNR-E134

ASSISTIVE TECHNOLOGY CHALLENGE

ECTS: 6
Semester: Spring Semester 4

Lecturers: Prof. R. Gassert

Summary: The course covers the interdisciplinary topics relevant to the development of assistive technologies, including user needs derivation, innovation and rapid prototyping, user-centered design, usability, and efficiency evaluation. It is framed around a user-centered design challenge for a real-world use case (in groups of four students) in tight collaboration with persons with disabilities (challengers), with the goal of realizing an assistive technology solution adapted to the specific needs of each challenger.

Source: https://www.vvz.ethz.ch
376-1224-00L Assistive Technology Challenge

PNR-E135

TRANSFER OF TECHNOLOGIES INTO NEUROREHABILITATION

ECTS: 3
Semester: Spring Semester 4

Lecturers: Dr. P. Bruno, Prof. R. Riener, Dr. M. Altermatt

Summary: Gain insight into the technical basics of advanced technologies and the transfer into product development processes. Gain insight into the application, the development and integration of advanced technologies in clinical settings. This includes the advantages and limitations according to different pathologies and therapy goals. Get the opportunity to test advanced technologies in practical settings. Learn how to transfer theoretical concepts to actual settings in different working fields. Neurobiological principles applied to the field of neurorehabilitation. Clinical applications of advanced rehabilitation technologies. Visit medical technology companies, rehabilitation centers and labs to gain deeper insight into the development, application and evaluation of advanced technology.

Source: https://www.vvz.ethz.ch
376-1400-00L Transfer of Technologies into Neurorehabilitation

PNR-E331

NEURAL CONTROL OF MOVEMENT AND MOTOR LEARNING

ECTS: 4
Semester: Spring Semester 4

Lecturers: Prof. N. Wenderoth, Dr. M. Altermatt, Dr. C. Lustenberger, Dr. S Gerritzen

Summary: This course extends the students' knowledge regarding the neural control of movement and motor learning. Particular emphasis will be put on those methods and experimental findings that have shaped current knowledge of this area including fMRI, EEG, TMS, electrical brain stimulation and classical behavioural experiments. Knowledge of the neurophysiological basis underlying the neural control of movement and motor learning. One central element is that students have first hands-on experience in the lab where small experiments are independently executed, analysed and interpreted.

Source: https://www.vvz.ethz.ch
376-0202-00L Neural control of movement and motor learning

PNR-E132

REHABILITATION ENGINEERING II: REHABILITATION OF SENSORY AND VEGETATIVE FUNCTIONS

ECTS: 3
Semester: Fall Semester 5

Lecturers: Prof. R. Riener, Dr. C. Awai

Summary: Classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits are presented. Focus is on the restoration and treatment of the human sensory and vegetative system. Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

Source: https://www.vvz.ethz.ch
376-1219-00 Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

PNR-E332

MOTOR NEUROREHABILITATION

ECTS: 3
Semester: Fall Semester 5

Lecturers: Prof. M. Branscheidt, Prof. A. Luft, Dr. R. Gonzenbach, Dr. B. Zörner, Ass. Prof. C. Bauer, Dr. C. Awai, Dr. S. Giovanoli, Dr. L. Legrand

Summary: This course provides a holistic, clinical view on the in- and outpatient rehabilitation process of neurological diseases with a special focus on movement deficits. Pharmacological, training and medical device-supported interventions with their potential and limitations are discussed from a clinical perspective along the patient journey – covering the different phases of inpatient rehab.

Source: https://www.vvz.ethz.ch
376-1222-00L Motor Neurorehabilitation

Lake Lucerne Institute AG
Rubistrasse 9
CH-6354 Vitznau

www.llui.org/education