Virtual Exchange Program

Fundamentals of Biomedical Imaging

Start date: 17/02/2020, **End date:** 29/05/2020
Platform: courseware.epfl.ch

Ecole Polytechnique Fédérale de Lausanne

COURSE SYNOPSIS

Domain: Physics

Title(s) of the course(s) as it appears on the platform: Fundamentals of Biomedical Imaging: MRI & Ultrasounds, X-ray, PET and applications

Language (ISO-639-1 code): en

Short description of the course: The goal of this course is to illustrate how modern principles of basic science approaches are integrated into the major biomedical imaging modalities of importance to biology and medicine, with an emphasis on those of interest to in vivo.

Instructor(s): Rolf Gruetter

Level: MA all years

ECTS: 4.0

Workload in student hours: 120.0

Semester: 1: jan-june

Full course description: This course covers the physical principles of major in vivo bio-imaging modalities, i.e., ultrasound, computed tomography, emission computed tomography, positron emission tomography and magnetic resonance imaging. We will show how existing physical principles transcend into bio-imaging and establish an important link into life sciences, illustrating the contributions physics can make to life sciences. In the lectures, practical examples will be shown to illustrate the respective imaging modality, its use, premise and limitations, and biological safety will be touched upon. The student will develop a good understanding of the mechanisms leading to tissue contrast of the bio-imaging modalities covered in this course, including the inner workings of the scanner and how they define the range of possible biomedical applications. Based on this course, the student will be able to judge which imaging modality is adequate for specific life science needs and to understand the limits and promises of each modality. 1. Introduction to the course, importance and essential elements of bioimaging - lab visit of CIBM 2. Ultrasound imaging; ionizing radiation and its generation 3. X-ray imaging - when the photon bumps into living tissue, radioprotection primer 4. Computed tomography - From projection to image 5. Emission tomography - what are tracers and how to "trace" them in your body, x-ray detection, scintillation principle 6. Positron emission tomography (PET) - imaging anti-matter annihilation 7. Tracer kinetics - modeling of imaging data 8. Introduction to biological magnetic resonance (MR) - Boltzmann distribution, from spins to magnetization 9. Excitation of spins, Relaxation, the Basis of MR contrast (The Bloch Equations) 10. MR spectroscopy: In vivo Biochemistry, without chemistry ... 11. From Fourier to image: Principles of MR image formation, k-space - echo formation 12. Basic MRI contrast mechanisms, BOLD fMRI, contrast agents 13. Spin gymnastics: Imaging Einstein's random walk - fiber tracking. Overview of imaging modalities treated in this course

Prerequisites: General Physics I-III (general physics courses at EPFL)

Link to course on platform: https://courseware.epfl.ch/courses/course-v1:EPFL+PHYS438a+2019_1/course/, https://courseware.epfl.ch/courses/course-v1:EPFL+PHYS438+2019_1/course/

Link to course in University studyplan: http://isa.epfl.ch/imoniteur_ISAP/!GEDPUBLICREPORTS.pdf?ww_i_reportModel=1696552884&ww_i_reportModelXsl=1696552963&ww_i_itemplan=2372876106&ww_c_langue=fr

Course registration opening date: 14/01/2020

Course registration deadline: 17/02/2020

Course withdraw date: 04/05/2020

Midterm: No

Midterm details: -

Exam period start: 15/06/2020

Exam period end: 04/07/2020

Exam date: -

Exam timing: Synchronous (exam needs to take place at the same date and time everywhere)

Exam start time: -

Exam end time: -

Time zone (at the time of the exam, DST): UTC+2

Exam registration date: 04/05/2020

Exam resit available: No

Exam resit period start: -

Exam resit period end: -

Exam resit date: -

Exam resit time start: -

Exam resit time end: -

Time zone (at the time of the resit of the exam, DST): -

Final exam type: Written

Final exam details: What you should be capable of: Have an active understanding of the essential principles of operation of ultrasound, x-ray imaging (CT), SPECT, PET and nuclear magnetic resonance (MRI). Understand the factors defining the limitations of spatial resolution and sensitivity for each of the aforementioned modality. Understand how the principles of operation define the applications for which these biomedical imaging modalities can be used Able to describe/analyze typical applications. Form of the exam: 4 situations/problems to analyze* Maximum of 18 points, e.g. two provide 4 pts, 2 provide 5 pts Each contains several subquestions (definitions, concepts and calculations are possible), typically related and of escalating difficulty Answers are to be written in pen on the provided exam sheets provided by us (your name is already printed - all sheets must be returned) Indicate clearly your final response/answer including a brief justification (draft sheets will not be considered) Allowed at the exam: One sheet A4 with handwritten notes on both pages To bring to the exam: Blue pen, ruler Calculations calculations should be possible without calculator* All results with two significant digits only and with units, e.g. 4.3·10-6eV We will provide values for material constants, and fundamental constants, e.g. k, c, eV, h, me *a non-graphical calculator is nonetheless allowed Not allowed Any form of electronic/digital support/communication/memory Questions: Assistants will not answer any questions to avoid confusion Toilets: No trips to the bathroom

Exam requirements for home university (computer, VOIP, recording materials): proctored room

Cap (maximum number of exchange students): 10.0

Offered to which partenrs: -, All partners of the Alliance(s) selected above

Link to course image: https://drive.google.com/open?id=102xwKXUMWy7juYaszYBVgIzGvBBqs_Gz