ETH-441

Advanced Techniques for the Risk Analysis of Technical Systems

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné par l'ETHZ

Content

EPFL

ETH-530

Advanced topics in nuclear reactor materials

Pouchon Manuel A., Spaetig Philippe, Streit Marco

Cursus	Sem.	Type
Nuclear engineering	MA3	Obl.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours donné par EPFL à PSI-Villigen

Summary

To comprehend advanced aspects of materials science as applied to nuclear power (fission and fusion), to get acquainted with materials for advanced plants, advanced damage characterization and life-time assessments

Content

- Materials for advanced nuclear plants
- Fuel behaviour under high burnup conditions
- Fuel behaviour under hypothetical accident conditions (RIA, LOCA)
- Important materials parameters
- Response of materials to high temperatures / high irradiation levels
- Advanced analytical tools for damage assessment
- Modeling of materials behaviour
- Working with highly radioactive materials
- Discussion of results from current research projects

Learning Prerequisites

Recommended courses

Nuclear fuels & materials

Learning Outcomes

By the end of the course, the student must be able to:

- Systematize Fuel behaviour under high burnup conditions
- Specify the role of material parameters in plant integrity assessment
- Formulate material behaviour under high temperature/high irradiation level

Transversal skills

- Make an oral presentation.
- Summarize an article or a technical report.

• Access and evaluate appropriate sources of information.

Teaching methods

Course takes place at PSI

Assessment methods

Exams will take place between mid-December and the end of January except during the 10 days of public holidays (Christmas-New Year)

ETH-532

Beyond-design-basis safety

Manera Annalisa, Vacat .

Cursus	Sem.	Type
Nuclear engineering	MA3	Obl.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné par l'ETHZ à PSI-Villigen

Content

Assessment methods

Exams will take place between mid-December and the end of January except during the 10 days of public holidays (Christmas-New Year)

EPFL

ETH-427 **Biomedical Imaging**

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	6
Session	Summer
Semester	Spring
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	5 weekly
Number of positions	

Remark

cours donné à l'ETHZ

Content

ETH-433

Computational Multiphase Thermal Fluid Dynamics

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné par l'ETHZ

Content

EPFL

ETH-444

Computational Neuroimaging Clinic

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	Oral
Workload	90h
Weeks	14
Hours	**2 weekly**
Lecture	2 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

ETH-533

Decommissioning of nuclear power plants

Pautz Andreas

Cursus	Sem.	Type
Nuclear engineering	MA3	Obl.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours donné par l'EPFL au PSI

Summary

Characterization and survey prior to dismantling. Technologies for segmentation and dismantling. Decontamination and remediation. Materials and wast management. Site characterization and environmental monitoring.

Content

The use of imaging and remote sampling systems is discussed, as well as novel detection and sample analysis technologies. Experience with robotics, remote systems and innovative cutting technologies are presented. A wide array of subjects including understanding of chemical and physical processes being used for decontamination. Addressing of challenges and technologies and fundamental research to better understand interactions between waste, packaging and disposal environs. Site characterization towards end state, post decommissioning challenges and technologies. Exploring the obstacles that must be overcome bring innovative solutions and technologies to bear on nuclear decommissioning. Reference is made to the challenges of getting new technologies into the field of decommissioning projects. A survey of decommissioning costing and human resources needs of skills and mind-setting is given.

Learning Outcomes

By the end of the course, the student must be able to:

Transversal skills

- Access and evaluate appropriate sources of information.

Assessment methods

oral exam
Exams will take place between mid-December and the end of January except during the 10 days of public holidays (Christmas-New Year)

EPFL

PHYS-490 **Elective project nuclear engineering**

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA1, MA2, MA3, MA4	Opt.

Language of teaching	English
Credits	8
Session	Winter, Summer
Semester	Fall
Exam	During the semester
Workload	240h
Weeks	14
Hours	**8 weekly**
Project	8 weekly
Number of positions	

Summary

The elective project is designed to train the students in the solution of specific engineering problems related to nuclear technology. This makes use of the technical and social skills acquired during the master's programm.

Content

The elective project has the purpose to train the students in the solution of specific engineering problems related to nuclear technology. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.
It can be done during the first 3 semesters at EPFL, ETHZ or PSI.

Learning Outcomes

By the end of the course, the student must be able to:

- Analyze a technical problem

Transversal skills

- Write a scientific or technical report.

Assessment methods

Written project report and oral presentation

ETH-454

Electrochemical Energy Conversion and Storage Technologies

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Remark

cours donné par l'ETHZ

Content

EPFL

ME-409

Energy conversion and renewable energy

Maréchal François, Nguyen Tuong-Van

Cursus	Sem.	Type
Civil Engineering	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Energy Science and Technology	MA1, MA3	Obl.
Energy minor	H	Opt.
Environmental Sciences and Engineering	MA1, MA3	Opt.
Managmt, dur et tech	MA3	Opt.
Minor in Engineering for sustainability	H	Opt.
Nuclear engineering	MA1	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	1 weekly
Project	1 weekly
Number of positions	

Summary

This course presents an overview of (i) the current energy system and uses (ii) the main principles of conventional and renewable energy technologies and (iii) the most important parameters that define their efficiency, costs and environmental impacts.

Content

The course gives an **overview** of:

- **Energy systems and uses**
- **Thermodynamic, economic and environmental principles** relevant for energy conversion systems (energy and exergy efficiencies, levelised cost of energy, emission factors)
- **Power cycles** (Rankine, Brayton and combined cycles)
- **Thermal power plants** (coal, natural gas and nuclear)
- **Carbon capture, storage** and **use**
- **Heat pumps** and **Geothermal**
- **Wind** and **Hydro**
- **Solar (PV** and **Thermal)**
- **Biomass**
- **Energy storage**
- **Fuel cells**

Focus is on the presentation of the current energy system and uses (electricity, heat and mobility) and of the main conversion technologies (thermodynamics and processes) to satisfy our energy demands. The course does **not** go in details in the physics of each technology. The first half of the course is on the presentation of the **energy system**, **thermodynamics and conventional power sources**, and the other half on the **main renewable sources**. The **goal** is therefore (i) to describe the relation between the energy system and our demands, (ii) to explain the principles of each energy conversion technology and resources and assess their costs and impacts, (iii) assess their role in future energy systems.

Keywords

Energy system ; Energy conversion ; Fossil and renewable sources

Learning Prerequisites

Required courses

Physics I
Physics II

Recommended courses

This course is **recommended** to master students in their **first year -** as it presents different topics covered in more details in other courses, it is **NOT recommended** to take it in the second year if possible.

Important concepts to start the course

• Thermodynamics (conservation laws - 1st and 2nd principles)
• Conservation principles (energy, mass, momentum)

Learning Outcomes

By the end of the course, the student must be able to:

• Model energy conversion systems and industrial processes
• Draw the energy balances of an energy conversion system
• Describe the principles and limitations of the main energy conversion technologies
• Quantify the efficiency and the main emission sources of energy conversion processes
• Explain principles and limitations of the main energy conversion technologies
• Characterize fossil and renewable energy resources and their corresponding conversion technologies
• Explain the challenges related to energy: resources, energy services, economic and environmental impacts
• Compare energy conversion systems (efficiency, economics and impacts)
• Model energy conversion systems and industrial processes

Transversal skills

• Use a work methodology appropriate to the task.
• Demonstrate the capacity for critical thinking
• Write a scientific or technical report.
• Access and evaluate appropriate sources of information.
• Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.

Teaching methods

Ex-cathedra lectures of 2 hours per week, completed by 1 hour of exercises and 1 hour of project

Expected student activities

• Active participation to the **lecture sessions**
• **Exercices** consisting of theory questions and case studies, for the exam preparation
• **Mini-project** consisting in proposing an energy transition pathway for Switzerland

Assessment methods

• Written exam at the end of the semester (60%)
• Intermediate and final project report (40%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Notes/Handbook

The course material consists of the following:

- Course compendium (lectures, exercises, solutions, project and former exams with corrections), available as a .pdf and on a dedicated website
- Slides and Pre-recorded videos, available on Moodle and on a SWITCHtube channel

Note that the course compendium and the slides/videos present the same content, the main difference lies in the addition of examples and further details in the coursebook in case of interest or need of explanations. This is done so that the interested student can choose the most suitable material and follow the course in case of conflict with other courses.

Websites

- http://moodle.epfl.ch
- http://www.energyscope.ch

Moodle Link

- https://go.epfl.ch/ME-409

Videos

- https://tube.switch.ch/channels/90cbb52f

PHYS-405

Experimental methods in physics

Cantoni Marco, Dwir Benjamin

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

The course's objectivs are: Learning several advenced methods in experimental physics, and critical reading of experimental papers.

Content

- **Noise and interference:** Their origins, their influence on experimental results, methods for noise and interference reduction
- Scanning probe microscopy (SPM): Principles of operation of the scanning tunneling microscope and atomic force microscope, Advanced scanning microscopy techniques, applications
- Optical spectroscopys: The elements of a modern spectroscopy system; different methods of spectral dispersion and their advantages, optical detectors. Related methods: raman spectroscopy, cathodoluminescence.
- Electron microscopy: Transmission and scanning microscopes, their principles of operation, observation tecniques, uses ...
- Structural characterization: RX, electron diffraction, ...

Keywords

Noise, Scanning probe microscopy, optical spectroscopy, transmission electron microscopy, scanning electron microscopy, electron diffraction, X-ray diffraction

Learning Prerequisites

Recommended courses

Basis courses in physics

Important concepts to start the course

fundamentals of optics, electromagnetics, atomic and solid-state physics

Learning Outcomes

By the end of the course, the student must be able to:

- Integrate the notions of critical reading of articles
- Assess / Evaluate scientific articles, their quality and defaults
- Interpret knowledge of several specific experimental methods

Transversal skills

- Communicate effectively, being understood, including across different languages and cultures.
- Give feedback (critique) in an appropriate fashion.
- Demonstrate the capacity for critical thinking
- Access and evaluate appropriate sources of information.
- Make an oral presentation.
- Summarize an article or a technical report.

Teaching methods

- Ex cathedra lectures on specific experimental techniques
- Students' presentations of scientific articles

Expected student activities

Participation in class is encouraged.
Students are expected to give a short presentation of a scientific article.

Assessment methods

oral exam (100%)

Supervision

Others	Moodle

Resources

Notes/Handbook

All is put on the Moodle site

Moodle Link

- https://go.epfl.ch/PHYS-405

EPFL

ETH-401 **Fuel Cycle and Waste Managment**

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné par l'ETHZ

Content

ME-453 **Hydraulic turbomachines**

Vagnoni Elena

Cursus	Sem.	Type
Energy Science and Technology	MA1, MA3	Obl.
Energy minor	H	Opt.
Mechanical engineering minor	H	Opt.
Mechanical engineering	MA1, MA3	Opt.
Mechanics		Opt.
Nuclear engineering	MA1	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	3 weekly
Exercises	1 weekly
Number of positions	

Summary

Master lecture on Hydraulic Turbomachines: impulse and reaction turbines,pumps and pump-turbines.

Content

- Turbomachine equations, mechanical power balance in a hydraulic machines, moment of momentum balance applied to the runner/impeller, generalized Euler equation.
- Hydraulic characteristic of a reaction turbine, a Pelton turbine and a pump, losses and efficiencies of a turbomachine, real hydraulic characteristics.
- Similtude laws, non dimensional coefficients, reduced scale model testing, scale effects.
- Cavitation, hydraulic machine setting, operating range, adaptation to the piping system, operating stability, start stop transient operation, runaway.
- Reaction turbine design: general procedure, general project layout, design of a Francis runner, design of the spiral casing and the distributor, draft tube role, CFD validation of the design, design fix, reduced scale model experimental validation.
- Pelton turbine design: general procedure, project layout, injector design, bucket design, mechanical problems.
- Centrifugal pump design: general architecture, energetic loss model in the diffuser and/or the volute, volute design, operating stability.
- Sustainability in turbomachines manufacturing and operation

Learning Prerequisites

Recommended courses

Incompressible Fluids Mechanics
Introduction to turbomachines

Learning Outcomes

By the end of the course, the student must be able to:

- Formulate the operating point of a hydraulic turbomachine
- Specify a type of hydraulic turbine
- Sketch the layout of a hydraulic turbomachine
- Select appropriately the dimensions of a hydraulic turbomachine

Transversal skills

- Use a work methodology appropriate to the task.
- Communicate effectively with professionals from other disciplines.
- Assess one's own level of skill acquisition, and plan their on-going learning goals.

Teaching methods

ex cathedra lectures with working case studies

Expected student activities

attendance at lectures completing exercises and reading written material

Assessment methods

written exam

Resources

Bibliography

P. HENRY: Turbomachines hydrauliques - Choix illustré de réalisation marquantes, PPUR, Lausanne, 1992.
Franc, Avellan et al., Cavitation, EDP Grenoble, 1994
Handout and Scientifc Litterature from LMH, Industry, International Association

Ressources en bibliothèque

- Turbomachines hydrauliques / Henry
- Cavitation / Franc

Notes/Handbook

slides handout Handbook

Moodle Link

- https://go.epfl.ch/ME-453

Prerequisite for

Cavitation, Hydroacoustic, Master Project

EPFL

MICRO-511

Image processing I

Unser Michaël, Van De Ville Dimitri

Cursus	Sem.	Type
Computational and Quantitative Biology		Opt.
Computational science and Engineering	MA1, MA3	Opt.
Computational science and engineering minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Digital Humanities	MA1, MA3	Opt.
Environmental Sciences and Engineering	MA1, MA3	Opt.
Life Sciences Engineering	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.
Minor in Imaging	H	Opt.
Minor in life sciences engineering	H	Opt.
Neuro-X minor	H	Opt.
Neuro-X	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Photonics minor	H	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Summary

Introduction to the basic techniques of image processing. Introduction to the development of image-processing software and to prototyping using Jupyter notebooks. Application to real-world examples in industrial vision and biomedical imaging.

Content

- **Introduction**. Image processing versus image analysis. Applications. System components.
- **Characterization of continuous images**. Image classes. 2D Fourier transform. Shift-invariant systems.
- **Image acquisition**. Sampling theory. Acquisition systems. Histogram and simple statistics. Max-Lloyd quantization (K-means).
- **Characterization of discrete images and linear filtering**. z-transform. Convolution. Separability. FIR and IIR filters.
- **Morphological operators**. Binary morphology (opening, closing, etc.). Gray-level morphology.
- **Image-processing tasks**. Preprocessing. Matching and detection. Feature extraction. Segmentation.
- **Convolutional neural networks**. Basic components. Operator-based formalism. CNN in practice: denoising and segmentation.

Learning Prerequisites

Required courses

Signals and Systems I & II (or equivalent)

Important concepts to start the course

1-D signal processing: convolution, Fourier transform, z-transform

Learning Outcomes

By the end of the course, the student must be able to:

- Exploit the multidimensional Fourier transform
- Select appropriately Hilbert spaces and inner-products
- Optimize 2-D sampling to avoid aliasing
- Formalize convolution and optical systems
- Design digital filters in 2-D
- Analyze multidimensional linear shift-invariant systems
- Apply image-analysis techniques
- Construct image-processing software
- Elaborate morphological filters
- Exploit the multidimensional Fourier transform
- Select appropriately Hilbert spaces and inner-products
- Optimize 2-D sampling to avoid aliasing
- Formalize convolution and optical systems
- Design digital filters in 2-D
- Analyze multidimensional linear shift-invariant systems
- Apply image-analysis techniques
- Construct image-processing software

Transversal skills

- Use a work methodology appropriate to the task.
- Manage priorities.
- Use both general and domain specific IT resources and tools

Assessment methods

- 70% final exam
- 30% IP labs during semester

Resources

Moodle Link

- https://go.epfl.ch/MICRO-511

ETH-445

Introduction to Quantum Mechanics for Engineers

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

PHYS-455

Introduction to medical radiation physics

Bochud François

Cursus	Sem.	Type
Nuclear engineering	MA1	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course covers the physical principles underlying medical diagnostic imaging (radiography, fluoroscopy, CT, SPECT, PET, MRI), radiation therapy and radiopharmacy. The focus is not only on risk and dose to the patient and staff, but also on an objective description of the image quality.

Content

Medical applications of ionizing radiations
Physics of medical imaging
Risk and radiation
Radiography & Mammography
Computer tomography (CT)
Radioscopy
Receiver operating characteristics (ROC)
Planification of a radiotherapy treatment
Radiotherapy treatment devices
Imaging in radiotherapy and advanced treatment techniques
Radiopharmaceutical products
Physics of single-photon emission computed tomography (SPECT)
Physics of positron emission tomography (PET)

Keywords

medical imaging, radiation therapy, risk, radiopharmacy

Learning Prerequisites

Recommended courses

This course has many synergies with the Radiation biology, protection and applications course where the basics of radiation physics and some aspects of radiation protection are very useful to follow the present course.

Learning Outcomes

By the end of the course, the student must be able to:

- Describe the main parts of an x-ray device from a physical point of view
- Describe the main differences between the radiography units and the fluoroscopy units

- Explain the principle of CT image acquisition

Teaching methods

Ex-cathedra with integrated individual exercises

Assessment methods

Written, Multiple Choice Question exam

Resources

Bibliography

Course in general

- William R. Hendee and E. Russell Ritenour, "Medical Imaging Physics", Wiley-Liss, 4th edition, 2002
- The Essential Physics of Medical Imaging, Third Edition, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boone, Lippicott 2012

Radiopharmaceutical products

- Philip Elsinga, Sergio Todde, Ivan Penuelas, Geerd Meyer, Brit Farstad, Alain Faivre-Chauvet, Renata Mikolajczak, Gerrit Westera, Tanja Gmeiner-Stopar, Clemens Decristoforo, Radiopharmacy Committee of the EANM, "Guidance on current good radiopharmacy practice (cGRPP) for the small-scale preparation of radiopharmaceuticals", Eur J Nucl Med Mol Imaging 2010, DOI 10.1007/s00259-010-1407-3

Physics of single-photon emission computed tomography (SPECT)

- SPECT in the Year 2000: Basic Principles MarkW. Groch and William D. Erwin, J Nucl Med Technol 2000; 28:233â##244
- Physics in nuclear medicine, S.R. Cherry, J.A. Sorenson, M.E. Phelps, Saunders Elsevier 2012 (forth edition)

Physics of positron emission tomography (PET)

- Positron Emission Tomography: A Review of Basic Principles, Scanner Design and Performance, and Current Systems Pat Zanzonico, Seminars in Nuclear Medicine, Vol XXXIV, No 2 (April), 2004: pp 87-111
- Physics in nuclear medicine, S.R. Cherry, J.A. Sorenson, M.E. Phelps, Saunders Elsevier 2012 (forth edition)

Dose to the patient

- Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog, Fred A. Mettler et al. Radiology: Volume 248: Number 1â##July 2008

Risk and radiation

- T. Rob Goodman, Maxwell Amurao, "Medical Imaging Radiation Safety for the Female Patient: Rationale and Implementation", RadioGraphics 2012; 32:1829â##1837
- Francis R. Verdun, FranÃ§ois Bochud, FranÃ§ois Gudinchet, Abbas Aroua, Pierre Schnyder, Reto Meuli, "Radiation Risk: What You Should Know to Tell Your Patient", Radiographics 2008; 28:1807â##1816

Receiver operating characteristics (ROC) and hypothesis testing

- Anvari A, Halpern EF, Samir AE. Statistics 101 for Radiologists. RadioGraphics 35:1789-1801 (2015)

Radiation therapy

- E. Podgorsak, Radiation Oncology Physics: a handbook for teachers and students, IAEA, 2005, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1196_web.pdf

Références suggérées par la bibliothèque

- William R. Hendee and E. Russell Ritenour, "Medical Imaging Physics"
- The Essential Physics of Medical Imaging, Third Edition, Jerrold T. Bushberg

Moodle Link

- https://go.epfl.ch/PHYS-455

PHYS-448 Introduction to particle accelerators

Seidel Mike

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The course presents basic physics ideas underlying the workings of modern accelerators. We will examine key features and limitations of these machines as used in accelerator driven sciences like high energy physics, materials and life sciences.

Content

Overview, history and fundamentals
Transverse particle dynamics (linear and nonlinear)
Longitudinal particle dynamics
Synchrotron radiation and related dynamics
Linear and circular accelerators
Acceleration and RF-technology
Beam diagnostics
Accelerator magnets
Medical application of accelerators
Future projects

Learning Outcomes

By the end of the course, the student must be able to:

- Design basic linear and non-linear charged particles optics
- Elaborate basic ideas of physics of accelerators
- Use a computer code for optics design
- Optimize accelerator design for a given application
- Estimate main beam parameters of a given accelerator

Transversal skills

- Communicate effectively with professionals from other disciplines.
- Use both general and domain specific IT resources and tools

Teaching methods

lecture based teaching using slides and blackboard,
occasionally inquiry based learning,
using Jupiter notebooks to simulate accelerator dynamics,

Application of knowledge through concrete exercises and provision of individual feedback in tutorials

Expected student activities

working on weekly problems, submitting the solutions and participation in the computer tutorials

Assessment methods

written exam

Resources

Moodle Link

- https://go.epfl.ch/PHYS-448

ETH-446

Magnetic Resonance Imaging in Medicine

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

ETH-442

Materials Analysis by Nuclear Techniques

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	6
Session	Summer
Semester	Spring
Exam	Oral
Workload	180h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

ETH-452

Medical Physics II

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	6
Session	Summer
Semester	Spring
Exam	Oral
Workload	180h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné à l'ETHZ

Content

ETH-453

Micro and Nano-Tomography of Biological Tissues

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Remark

cours donné à l'ETHZ

Content

EPFL

ME-454 **Modelling and optimization of energy systems**

Maréchal François

Cursus	Sem.	Type
Civil Engineering	MA1, MA3	Opt.
Energy Science and Technology	MA1, MA3	Opt.
Energy minor	H	Opt.
Ing.-chim.	MA1, MA3	Opt.
Mechanical engineering minor	H	Opt.
Mechanical engineering	MA1, MA3	Opt.
Minor in Integrated Design, Architecture and Sustainability	H	Opt.
Nuclear engineering	MA1	Opt.
Systems Engineering minor	H	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The goal of the lecture is to present and apply techniques for the modelling and the thermo-economic optimisation of industrial process and energy systems. The lecture covers the problem statement, the solving methods for the simulation and the single and multi-objective optimisation problems.

Content

- Concepts of Computer Aided Process System Engineering methods to tackle the problems of energy conversion systems modelling and optimisation. The students will acquire a methodology to state the problem, identify the solving procedure, solve the problem and analyse the results;
- Definition of the basic system modelling concepts : state variables, energy and mass balances, simulation parameters and equations, degree of freedom analysis, different types of specifications, inequalities, objective functions;
- Energy systems equipments models;
- System models : flowsheets, degrees of freedom, sequential or simultaneous solving approach, numerical methods and their implications;
- Measurement data reconciliation and parameter identification;
- Calculating systems performances : operating cost, efficiency, environmental impact, investments, thermo-economic and environomic performances;
- Stating and solving optimization problems : decision variables, objective functions and constraints, solving strategies, numerical methods and their implications;
- Realization of a case study.

Keywords

Process system engineering, Process simulation, optimization

Learning Prerequisites

Recommended courses

Prerequisite skills

- Master the concepts of mass, energy, and momentum balance, E1 (Thermodynamique et énergétique I)
- Compute the thermodynamic properties of a fluid, E2 (Thermodynamique et énergétique I)
- Master the concepts of heat and mass transfer, E3 (Heat and mass transfer)
- Understand the main thermodynamic cycles, E5 (Thermodynamique et énergétique I)
- Notion of optimization (Introduction à l'optimisation différentiable)

Learning Outcomes

By the end of the course, the student must be able to:

- Master the concepts of thermodynamic efficiency, E6
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E22
- Analyse the energy and exergy efficiency of industrial energy systems, E23
- Model, design and optimize energy conversion systems and ind ustrial processes, E24
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E20
- Explain and apply the concepts of thermodynamic efficiency, E6
- Analyze the energy and exergy efficiency of industrial energy systems, E21
- Model , design and optimize energy conversion systems and industrial processes, E22

Transversal skills

- Write a scientific or technical report.
- Make an oral presentation.
- Keep appropriate documentation for group meetings.
- Access and evaluate appropriate sources of information.

Teaching methods

The course is organised as theoretical sessions and the resolution of a real case study to be realised by a student team coached by an assistant.

Expected student activities

Participation to a team project and contribution to the report.
Active participation to the lectures and mastering the theoretical concepts applied to solve the project.

Assessment methods

An oral exam will concern the theory and its application in the case study.

Resources

Bibliography

All the material can be downloaded from the moodle website (http://moodle.epfl.ch/course/view.php?id=11).
Printed version of the lecture notes can be ordered.

Moodle Link

- https://go.epfl.ch/ME-454

Videos

- http://www.klewel.com/conferences/epfl-energy-systems/

ETH-447

Monte Carlo in Medical Physics

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

ETH-434

Multiphase Flow

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Remark

cours donné par l'ETHZ

Content

EPFL

PHYS-640 **Neutron and X-ray Scattering of Quantum Materials**

Fogh Ellen, Rønnow Henrik M., Schmitt Thorsten

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.
Physics		Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Remark

Next time: Fall

Summary

Neutron and X-ray scattering are some of the most powerful and versatile experimental methods to study the structure and dynamics of materials on the atomic scale. This course covers basic theory, instrumentation and scientific applications of these experimental methods.

Content

The application of neutron and X-ray scattering spans from crystalline matter to bio-materials and engineering, including fields like magnetism and superconductivity. Similar to the vast possibilities with X-rays at synchrotron facilities like the Swiss Light Source at the Paul Scherrer Institute (PSI) in Switzerland, the European Synchrotron Radiation Facility in Grenoble, neutron scattering is a large-scale-facility technique with neutron sources among others at PSI in Switzerland, the Institute Laue-Langevin in Grenoble and a new joint European Spallation Source under construction in Sweden. The course provides an introduction to the dynamic experimental techniques of neutron and X-ray scattering and covers the following aspects:

1) Theory of the neutron scattering cross section
2) Neutron sources and neutron instrumentation
3) Neutron imaging, neutron reflectivity and neutron small angle scattering
4) Neutron diffraction, crystal structures
5) Inelastic neutron scattering, phonons
6) Magnetic neutron scattering, magnetic structures
7) Inelastic magnetic neutron scattering, magnetic dynamics
8) Theory of the interaction between X-rays and matter
9) X-ray sources and X-ray instrumentation
10) X-ray absorption spectroscopy
11) X-ray emission spectroscopy and Resonant Inelastic X-ray Scattering (RIXS)
12) Resonant Elastic X-ray Scattering (REXS)
13) Inelastic X-ray Scattering
14) Time resolved pump-probe X-ray spectrosocpy

The course contains lectures and exercise sessions. Exercise sessions will contain derivation of relevant formulas, Monte-Carlo simulation of neutron scattering experiments, and discussions of representative scientific articles using X-ray and neutron scattering techniques. The course includes performing a real neutron or X-ray experiment and a tour of the large-scale experimental research facilities at the PSI.

Keywords

Neutron Scattering, X-ray scattering, X-ray spectroscopy, diffraction, crystal structures, lattice vibrations, phonons, magnetism, spin waves, magnons, neutron imaging

Learning Prerequisites

Required courses

Solid State Physics 1 and 2, basic quantum mechanics and basic atomic physics.

Learning Outcomes

By the end of the course, the student must be able to:

- Plan, predict and interpret neutron scattering experiments
- Read and evaluate articles containing neutron scattering results
- predict and interpret neutron and X-ray scattering experiments.
- Read and evaluate articles containing neutron and X-ray scattering results

Assessment methods

Oral

Resources

Bibliography

"Elements of Modern X-ray Physics" by Des McMorrow and Jens Als-Nielsen (2nd edition)
"Neutron scattering â## Theory, Instrumentation and Simulation"##, lecture notes by Kim Lefmann
Relevant scientific articles

Ressources en bibliothèque

- Neutron scattering : Theory, Instrumentation and Simulation / Lefmann
- Elements of Modern X-ray Physics / McMorrow

Websites

- http://Lab web page: lqm.epfl.ch

ETH-402

Nuclear Fuels and Materials

Pouchon Manuel A., Spaetig Philippe

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Obl.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Remark

cours donné à l'ETHZ

Content

ETH-531

Nuclear computations lab

Ferroukhi Hakim, Freixa Terradas Jordi, Pautz Andreas

Cursus	Sem.	Type
Nuclear engineering	MA3	Obl.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	1 weekly
Exercises	3 weekly
Number of positions	

Remark

Cours donné par EPFL à PSI-Villigen

Summary

To aquire hands-on experience with the running of large computer codes in relation to the static analysis of nuclear reactor cores and the multi-physics simulation of nuclear power plant (NPP) dynamic behaviour

Content

Lattice (assembly) calculations
Thermal-hydraulic analysis
Reactor core analysis
Multi-physics core dynamics calculations
Best-estimate NPP transient analysis

Learning Prerequisites

Recommended courses

Special topics in reactor physics, nuclear safety

Learning Outcomes

By the end of the course, the student must be able to:

- Interpret the output of nuclear simulation software
- Compose simple input data for nuclear simulation software

Transversal skills

- Access and evaluate appropriate sources of information.
- Use both general and domain specific IT resources and tools

Assessment methods

Exams will take place between mid-December and the end of January except during the 10 days of public holidays (Christmas-New Year)

EPFL

PHYS-445 **Nuclear fusion and plasma physics**

Fasoli Ambrogio

Cursus	Sem.	Type
Auditeurs en ligne	H	Opt.
Energy Science and Technology	MA1, MA3	Opt.
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The goal of the course is to provide the physics and technology basis for controlled fusion research, from the main elements of plasma physics to the reactor concepts.

Content

1) Basics of thermonuclear fusion
2) The plasma state and its collective effects
3) Charged particle motion and collisional effects
4) Fluid description of a plasma
5) Plasma equilibrium and stability
6) Magnetic confinement: Tokamak and Stellarator
7) Waves in plasma
8) Wave-particle interactions
9) Heating and non inductive current drive by radio frequency waves
10) Heating and non inductive current drive by neutral particle beams
11) Material science and technology: Low and high Temperature superconductor - Properties of material under irradiation
12) Some nuclear aspects of a fusion reactor: Tritium production
13) Licensing a fusion reactor: safety, nuclear waste
14) Inertial confinement

Learning Prerequisites

Recommended courses

Basicknowledge of electricity and magnetism, and of simple concepts of fluids

Learning Outcomes

By the end of the course, the student must be able to:

- Identify the main physics challenges on the way to fusion
- Design the main elements of a fusion reactor
- Identify the main technological challenges of fusion

Teaching methods

Ex cathedra and in-class exercises

Assessment methods

oral examen (100%)

Resources

Websites

- https://spcnet.epfl.ch/nuclfus/

Moodle Link

- https://go.epfl.ch/PHYS-445

EPFL

PHYS-461

Nuclear interaction : from reactors to stars

Rochman Dimitri

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course will present an overview of the nuclear interactions for neutrons on nuclei below a few hundreds of MeV. The aspect of so-called "nuclear data" will be presented from the perspective of experiments, compilation, calculation, evaluation, processing and applications.

Content

The following subjects will be presented:

- Nuclear data needs: It is important to understand if, and where, nuclear data are needed, why, which accuracy is required from the applications or industries. Such needs concerns a large range of applications: energy, medical, waste and astrophysics. Each of these fields requires different knowledge on nuclear interactions with, either with neutrons, or protons, or both.
- Theoretical background: Many of the needs are covered by experimental knowledge, but not all. Some reactions cannot be easily measured, or are simply out of range with current technologies (for instance for with short-lived isotopes). What can we do in this case ? Part of the answer relies on theoretical understanding and the prediction power of current models (with their shortcoming). We will then explore (not in details) some of the important models, their range of applications, and what to do when nothing is known.
- Measurement facilities: The current knowledge of nuclear interactions, cross sections and uncertainties is based on measurements. In many instances, measurements are necessary due to the lack of prediction power for models. We will see the existing facilities, their advantages and drawback. We will also visit the installation worldwide, with a view on the future needs.
- Evaluation: Once quantities have been measured or calculated, they need to be presented to potential users. This step is called "evaluation". The outcome of the process is "what the users will see". It covers compiling measurements, combining them with theoretical predictions, formatting, and processing in forms that users need. We will go through these steps, and you will globally understand the importance of these steps.
- Applications: finally, we will see how these nuclear data are used. What are the applications, what are the needs, and how users can propose feedback to influence new measurements, or new calculations.

Keywords

Nuclear data, interaction, reaction, uncertainty, spent nuclear fuel

Learning Outcomes

By the end of the course, the student must be able to:

- Use applications codes

Assessment methods

written exam

MATH-468

Numerics for fluids, structures & electromagnetics

Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Computational science and engineering minor	H	Opt.
Ing.-math	MA1, MA3	Opt.
Mathématicien	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.

Language of teaching	English
Credits	5
Session	Winter
Semester	Fall
Exam	Oral
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Remark

Pas donné en 2024-25. Cours donné en alternance tous les deux ans.

Summary

Cours donné en alternance tous les deux ans

Content

Keywords

Partial differential equations, saddle point problems, finite element method, Galerkin approximation, stability and convergence analysis.

Learning Prerequisites

Required courses

Analysis I II III IV, Numerical Analysis, Numerical Approximations of PDEs

Recommended courses

Sobolev spaces and elliptic equations,

Important concepts to start the course

- Basic knowledge of functional analysis: Banach and Hilbert spaces, L^p spaces.
- Some knowledge on theory of PDEs: classical and weak solutions, existence and uniqueness.
- Basic concepts in numerical analysis: stability, convergence, condition number, solution of linear systems, quadrature formulae, finite difference formulae, polynomial interpolation.
- Basic information on finite element theory for elliptic problems

Learning Outcomes

By the end of the course, the student must be able to:

- Identify features of a PDE relevant for the selection and performance of a numerical algorithm.
- Assess / Evaluate numerical methods in light of the theoretical results.
- Implement numerical methods for saddle point problems

- Choose an appropriate method to solve a given differential problem
- Prove convergence of a discretisation scheme

Transversal skills

- Write a scientific or technical report.
- Make an oral presentation.

Teaching methods

Ex cathedra lectures, exercises in the classroom and computer lab sessions.

Expected student activities

- Attendance of lectures.
- Completing exercises.
- Solving problems with an academic software as Free FEM ++

Assessment methods

Oral

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

- S.C. Brenner, L.R. Scott. *The Mathematical Theory of Finite Element Methods*. Springer 2007.
- A. Ern, J-L. Guermond, *Theory and Practice of Finite Elements.* Springer 2004.
- D. Boffi, F. Brezzi, M. Fortin *Mixed Finite elements and Applications*, Springer Verlag. 2013.

Ressources en bibliothèque

- The Mathematical Theory of Finite Element Methods / S.C. Brenner & L.R. Scott
- Theory and Practice of Finite Elements / A. Ern & J-L. Guermond
- Mixed Finite elements and Applications / D. Boffi, F. Brezzi & M. Fortin

Notes/Handbook

Notes for each lectures will be provided every week.

Moodle Link

- https://go.epfl.ch/MATH-468

Videos

- http://Recording of the lectures will be provided after each lecture.

ETH-443

Physics Against Cancer: The Physics of Imaging and Treating Cancer

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	6
Session	Summer
Semester	Spring
Exam	Oral
Workload	180h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

ETH-404

Physics of Nuclear Reactor II

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Remark

cours donné à l'ETHZ

Content

PHYS-443

Physics of nuclear reactors

Hursin Mathieu, Pautz Andreas

Cursus	Sem.	Type
Nuclear engineering	MA1	Obl.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	Oral
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	4 weekly
Exercises	2 weekly
Number of positions	

Summary

In this course, one acquires an understanding of the basic neutronics interactions occurring in a nuclear fission reactor as well as the conditions for establishing and controlling a nuclear chain reaction.

Content

• **Brief review of nuclear physics**
- Historical: Constitution of the nucleus and discovery of the neutron
- Nuclear reactions and radioactivity
- Cross sections
- Differences between fusion and fission.

• **Nuclear fission**
- Characteristics - Nuclear fuel - Introductory elements of neutronics.
- Fissile and fertile materials.

• **Element of reactor design**
- flux and heat source distribution; properties of different coolants and technological consequences

• **LWR reactors technology**
- overview of the functional scheme of PWR and BWRs; fuel elements; compensation of excess reactivity in PWRs and BWRs (boron, etc,)

• **Neutron diffusion and slowing down**
- Monoenergetic neutrons - Angular and scalar flux
- Diffusion theory as simplified case of transport theory - Neutron slowing down through elastic scattering.

• **Multiplying media (reactors)**
- Multiplication factors - Criticality condition in simple cases.
- Thermal reactors - Neutron spectra - Multizone reactors - Multigroup theory and general criticality condition - Heterogeneous reactors.

• **Reactor kinetics**
- Point reactor model: prompt and delayed transients - Practical applications.

• **Reactivity variations and control**
- Short, medium and long term reactivity changes. Different means of control.

• **Advanced reactor designs**
- Breeding and transmutation; introduction into Gen-IV reactors

Learning Outcomes

By the end of the course, the student must be able to:

- Elaborate on neutron diffusion equation
- Formulate approximations to solving the diffusion equation for simple systems
- Classify nuclear reaction cross sections
- Develop for a nuclear reactor

Transversal skills

- Access and evaluate appropriate sources of information.
- Collect data.
- Use both general and domain specific IT resources and tools
- Write a scientific or technical report.

Teaching methods

Lectures, numerical exercises

Assessment methods

oral exam (50%)
group project (50%)

Resources

Moodle Link

- https://go.epfl.ch/PHYS-443

EPFL

PHYS-423 **Plasma I**

Theiler Christian Gabriel

Cursus	Sem.	Type
Energy minor	H	Opt.
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	Oral
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	2 weekly
Exercises	3 weekly
Number of positions	

Summary

Following an introduction of the main plasma properties, the fundamental concepts of the fluid and kinetic theory of plasmas are introduced. Applications concerning laboratory, space, and astrophysical plasmas are discussed throughout the course.

Content

I Collisional and relaxation phenomena
- Inelastic collisions: ionization and recombination, degree of ionization
- Elastic collisions: Coulomb collisions
- Isotropisation and thermalisation
- Plasma resistivity and the runaway regime

II Transport in plasmas
- Random walk and diffusion
- Ambipolar and cross-field diffusion
- Energy and particle confinement

III Waves in cold magnetized plasma
- Dielectric tensor
- Resonances and cut-offs
- Parallel and perpendicular propagation

IV Wave-particle interaction and kinetic description of waves in hot un-magnetized plasmas
- The Vlasov-Maxwell model
- Resonant wave-particle interaction and Landau damping
- Stability criteria and streaming instabilities
- Langmuir and ion-acoustic waves and instabilities

V Waves in hot magnetized plasmas
VI Examples of nonlinear effects

Learning Prerequisites

Recommended courses

PHYS-324: Classical Electrodynamics, PHYS-325: Introduction to Plasma Physics

Learning Outcomes

By the end of the course, the student must be able to:

- Manipulate the fundamental elements of the plasma fluid and kinetic theory

Teaching methods

Ex cathedra and exercises in class

Assessment methods

oral exam

Resources

Moodle Link

- https://go.epfl.ch/PHYS-423

ETH-448

Radiation Imaging for Industrial Applications

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

PHYS-451 **Radiation and reactor experiments**

Hursin Mathieu, Lamirand Vincent, Pakari Oskari Ville

Cursus	Sem.	Type
Nuclear engineering	MA1	Obl.

Language of teaching	English
Credits	6
Withdrawal	Unauthorized
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**4 weekly**
Practical work	4 weekly
Number of positions	**30**

It is not allowed to withdraw from this subject after the registration deadline.

Summary

The reactor experiments course aims to introduce the students to radiation detection techniques and nuclear reactor experiments. The core of the course is the unique opportunity to conduct reactor experiments, as the control rod calibration, and approach to critical.

Content

- Radiation detector systems, alpha and beta particles
- Radiation detector systems, gamma spectroscopy
- Introduction to neutron detectors (He-3, BF3)
- Slowing-down area (Fermi age) of Pu-Be neutrons in H2O
- Approach-to-critical experiments
- Buckling measurements
- Reactor power calibration
- Control rod calibration

Learning Outcomes

By the end of the course, the student must be able to:

- Apply measurement techniques for alpha, beta, gamma and neutron radiation detection.
- Carry out measurement techniques to obtain CROCUS reactor characteristics.
- Conduct both reactor power and control rod calibration.
- Plan the critical experiment.

Teaching methods

Instructions and supervision during lab work

Assessment methods

reports and oral examination during the semester

Resources

Bibliography

Handouts will be distributed

• James E. Martin, "Physics for Radiation Protection", Wiley-VCH (2nd edition, 2006)

• F.M. Khan, "The Physics of Radiation Therapy", Lippincott, Williams & Wilkins, (4th edition, 2010)

• G.C. Lowenthal, P.L. Airey, "Practical Applications of Radioactivity and Nuclear Reactions", Cambridge University Press (2001)

• K.H. Lieser, "Nuclear and Radiochemistry", Wiley-VCH (2nd edition, 2001)

Moodle Link

• https://go.epfl.ch/PHYS-451

PHYS-450

Radiation biology, protection and applications

Damet Jerome, Grilj Veljko, Pakari Oskari Ville

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Obl.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This is an introductory course in radiation physics that aims at providing students with a foundation in radiation protection and with information about the main applications of radioactive sources/substances in the industry. The course includes presentations, lecture notes and problem sets.

Content

- Radioactivity and interactions of ionising radiation in matter
- Health effects of ionising radiation
- Dosimetry and population exposure
- Space radiation dosimetry
- Radioisotope production using reactors and accelerators
- Industrial applications: radiation gauges, tracer techniques, radioisotope batteries, radiation imaging, radiography, etc.
- Applications in research: dating by nuclear methods, applications in environmental and life sciences, etc.

Learning Outcomes

By the end of the course, the student must be able to:

- Explain the origin ionising radiation and give a few examples of the origin of neutron radiation.
- Explain interactions of ionising radiations in matter.
- Explain biological/health effects of the ionising radiations
- Explain the principles of dosimetry
- Explain populationâ##s exposure and cite exposure levels
- Explain the principles of radiation protection, cite the dose limits
- Explain the concept of risk
- Describe the protection means for external and internal exposure
- Explain radiation shielding and give examples
- Explain the use of radiation in industrial and research applications.
- Explain exposure to the general population and cite exposure levels
- Explain the origin of ionising radiation
- Explain interactions of ionising radiation in matter.

- Explain biological/health effects of the ionising radiation
- Design appropriate radiation shielding for a given source or application

Assessment methods

Written, Multiple Choice Question exam

Resources

Bibliography

Handouts will be distributed

- James E. Martin, "Physics for Radiation Protection", Wiley-VCH (2nd edition, 2006)
- G.C. Lowenthal, P.L. Airey, "Practical Applications of Radioactivity and Nuclear Reactions", Cambridge University Press (2001)
- K.H. Lieser, "Nuclear and Radiochemistry", Wiley-VCH (2nd edition, 2001)

Ressources en bibliothèque

- Physics for Radiation Protection / Martin
- Nuclear and Radiochemistry / Lieser
- Practical Applications of Radioactivity and Nuclear Reactions / Lowenthal

Moodle Link

- https://go.epfl.ch/PHYS-450

PHYS-452

Radiation detection

Lamirand Vincent

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

The course presents the detection of ionizing radiation in the keV and MeV energy ranges. Physical processes of radiation/matter interaction are introduced. All steps of detection are covered, as well as detectors, instrumentations and measurements methods commonly used in the nuclear field.

Content

- **Interaction of radiation with matter at low energies**: X-rays/gammas, charged particles and neutrons up to MeV range, ionisation, nuclear cross sections.
- **Characteristics and types of detectors:** gas detectors, semiconductor detectors, scintillators and optical fibers, fission chambers, meshed and pixel detectors
- **Signal processing and analysis:** types of electronics, signal collection and amplification, particle discrimination, spatial and time resolution
- **Nuclear instrumentation and measurements:** principle of measurements, spectrometry, common detection instrumentations, applications in nuclear engineering and R&D.

Keywords

radiation detection; radiation-matter interaction; ionizing radiation; detector; signal processing; nuclear instrumentation; measurement methods

Learning Outcomes

By the end of the course, the student must be able to:

- Explain interaction processes of ionising radiation and matter
- Describe the production of a detection signal and its processing
- Explain the operation of all types of commonly used detectors
- Assess / Evaluate the detection system and method required for a specific measurement

Transversal skills

- Communicate effectively with professionals from other disciplines.

Teaching methods

Lectures, exercises, presentations, practice.

Expected student activities

Attendance at lectures and exercises, short presentations.

Assessment methods

Oral exam

Supervision

Assistants	Yes

Resources

Bibliography

Radiation detection and measurement, Glenn F. Knoll. Wiley 2010
Practical Gamma-Ray Spectrometry, Gordon R. Gilmore, Wiley & Sons 2008

Ressources en bibliothèque

- Practical Gamma-Ray Spectrometry, Gordon R. Gilmore
- Radiation detection and measurement, Glenn F. Knoll

Moodle Link

- https://go.epfl.ch/PHYS-452

EPFL

ETH-522

Reliability Engineering and quantitative risk analysis

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné à l'ETHZ

Content

Resources

Moodle Link

- https://go.epfl.ch/ETH-522

ETH-431

Renewable energy technologies II, energy storage and conversion

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné par l'ETHZ

Content

EPFL

ETH-590

Semester Project Nuclear Engineering

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA3	Obl.

Language of teaching	English
Credits	8
Session	Winter
Semester	Fall
Exam	During the semester
Workload	240h
Weeks	14
Hours	**8 weekly**
Project	8 weekly
Number of positions	

Summary

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

Content

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Learning Outcomes

By the end of the course, the student must be able to:

- Analyze a technical problem

Transversal skills

- Write a scientific or technical report.

EPFL

PHYS-595

Stage d'ingénierie (master en Génie nucléaire)

Profs divers *

Cursus	Sem.	Type
Génie nucléaire	MA2, MA3, MA4	Obl.

Langue d'enseignement	
Crédits	8
Session	Hiver, Eté
Semestre	Printemps
Examen	Pendant le semestre
Charge	240h
Semaines	14
Projet	8 hebdo
Nombre de places	

Résumé

The main objective of the 12-week internship is to expose master's students to the industrial work environment within the field of nuclear energy.

Contenu

The main objective of the 12-week internship is to expose master's students to the industrial work environment within the field of nuclear energy. During this period, students have the opportunity to be involved in on-going projects at the host institution.

Acquis de formation

A la fin de ce cours l'étudiant doit être capable de:

Compétences transversales

- Utiliser une méthodologie de travail appropriée, organiser un/son travail.
- Communiquer efficacement et être compris y compris par des personnes de languages et cultures différentes.

Méthode d'évaluation

an oral presentation could be asked by the company, not compulsory

ETH-450

Technology and Policy of Electrical Energy Storage

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné par l'ETHZ

Content

ETH-403

Technology and Safety of Nuclear Power Plants

Manera Annalisa

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	6
Session	Summer
Semester	Spring
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	4 weekly
Exercises	1 weekly
Number of positions	

Remark

cours donné à l'ETHZ

Content

Resources

Moodle Link

- https://go.epfl.ch/ETH-403

ETH-451

The energy challenge - the role of technology, business and society

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	
Semester	Spring
Exam	Oral
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content

ETH-449

Therapeutic Applications of Particle Physics: Principles and Practice of Particle Therapy

Profs divers *

Cursus	Sem.	Type
Nuclear engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	6
Session	Summer
Semester	Spring
Exam	Oral
Workload	180h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours donné par l'ETHZ

Content