ED2240 Introduction Course to Fusion Technology 6.0 credits

Introduktionskurs till fusionsteknologi

This is a translation of the Swedish, legally binding, course syllabus.

If the course is discontinued, students may request to be examined during the following two academic years

Establishment

Course syllabus for ED2240 valid from Spring 2010

Grading scale

A, B, C, D, E, FX, F

Education cycle

Second cycle

Main field of study

Electrical Engineering,Engineering Physics,Physics

Specific prerequisites

Students with good knowledge of physics and electromagnetics.

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

Under terrestrial conditions fusion plasmas must be surrounded by walls of a vacuum vessel and confined by strong external forces such as high power beams or magnetic fields. Energy stored in magnetically confined plasmas and the enormous temperature gradients between the plasma and the wall pose very severe requirements regarding the plasma edge shaping and selection of the most relevant materials for a thermonuclear fusion reactor. In future reactor devices, such as International Thermonuclear Experimental Reactor (ITER), the interaction of the plasma with surrounding materials in the vacuum vessel constitutes one of the main remaining engineering problems.

An additional goal of the course is to give the student better grounds for:

- Presentation of results and ideas;
- Communication with scientific and technical staff at fusion laboratories;
- Communication with teachers and students at summer schools on fusion plasma physics;
- Solving scientific or technical problems in fusion science and technology.

Course contents

Fusion Technology: Scope of the field.

Scope and structure of the course, requirements for approval.

Introduction to fusion and reactor construction: D-T fusion and energy release, main reactor components.

Underlying physics and chemistry in plasma – material interactions.

Mechanisms of wall erosion and their impact on plasma contamination: Erosion and re-deposition, mechanisms (underlying physics), erosion yield and material lifetime. Dust formation and risk related to dust. Fuel inventory.

Power loads and power handling in steady-state operation and in transient events

Wall components for a reactor-class machine: structure, testing of wall materials and components, test-beds.

Selection of armour materials for controlled fusion devices.

Materials for diagnostic components: ceramics.

Radiation induced damage in fusion reactor materials: definitions: displacement per atom, transmutation, neutron-induced effects (details), influence on ceramic materials.

Concept of IFMIF (International Fusion Material Irradiation Facility).

Tritium breeding blanket: blanket structure, structural and functional materials.

Tritium handling: tritium plant, remote handling and safety aspects.

Analysis of fusion reactor materials: methods for surface and bulk analysis, instrumentation (visit to laboratory).

Organisation and coordination of Fusion Research (Technology & Material Programme).

Disposition

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- Solving scientific or technical problems in fusion science and technology.

Course literature

ITER Physics Basis, Nuclear Fusion, Special Issue 2008.

Monograph: "Physical Processes of the Interaction of Fusion Plasmas with Solids", **W. Hofer and J. Roth (eds), Academic Press 1996.**

Review articles in the field fusion reactor materials

- Nuclear Fusion 41 (2001) 1697.
- Tutorial articles from Carolus Magnus Summer School (Fusion Science and Technology, vol. 53, T2, 2008
- Selected articles from Journal Nuclear Materials.

Examination

- SEM1 - Seminars, 2.0 credits, grading scale: A, B, C, D, E, FX, F
- TEN1 - Written exam, 2.0 credits, grading scale: A, B, C, D, E, FX, F
- TEN2 - Examination, 2.0 credits, grading scale: A, B, C, D, E, FX, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

Test (intermediate and final).

Presentation of problem solving (seminar).

To reach the learning objectives the student should:

- Participate actively in the course and prepare for discussion sessions
- Prepare and deliver two structured presentations (student seminars).

- Pass an intermediate test (70%) and final exam.
- Elaborate and present a project: oral presentation and report.

Other requirements for final grade

When completing the course, the students should be able to:

- Describe and distinguish different mechanisms of wall erosion and fuel retention.
- Explain and assess the impact of physical and chemical processes on erosion of wall material.
- Critically assess and motivate material choice for respective plasma-facing components.

· Compare and assess fuel inventory in different wall materials and assess its impact on the fuel cycle.

- Evaluate power loads to the wall during normal operation, disruptions and edge localised modes.
- Relate thermo-mechanical properties of materials (CFC, W, Be) to their response to power loads and
- Relate wall erosion to its impact on plasma operation.
- Explain causes for dust formation and assess the risk of such process for the reactor operation.
- Select methods for studies (analysis) and qualification of wall materials.
- Apply knowledge to experiment planning and conceptual design of: diagnostic for erosion-deposition measurement and propose the use of diagnostic for specific experiments in a controlled fusion device; plasma-facing components for testing under reactor conditions.

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.