Introduction

BNEN, the Belgian Nuclear higher Education Network organizes a interuniversity program for Master of Science in Nuclear Engineering. This program is organized in a highly modular way and taught in English to facilitate and enhance participation of foreign students in the frame of the European Master of Science in Nuclear Engineering within the ENEN-association. The BNEN program makes full use of the laboratory facilities and infrastructure of the Belgian Nuclear Research, the SCK•CEN.

The course on "Nuclear Reactor Theory" is free of charge for university registered students. Travel, lodging and other incurring cost are at own expenses. Participants from industry should contact the registration office.

Students

The course is open for graduate and post-graduate students. Knowledge of Physics and higher Mathematics are a prerequisite.

Application

Applicants should fill in the annexed Application Form and provide it with the requested additional information to the registration.

The number of participants is limited to 20. The applications are subject to a selection procedure.

Application deadline

The application deadline is December 13, 2004.

Venue

The course will take place at the SCK•CEN Club-House, Boeretang 200, B-2400 Mol, Belgium.

Registration & Information

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Travel Information

SCK•CEN is in Mol, Belgium, about 100 km northeast of Brussels and about 50 km east of Antwerp.

For a roadmap and itinerary: www.sckcen.be

By taxi from Brussels Airport to Mol: 1,5 h drive (*indicative rate € 150)*

By public transport from Brussels Airport:

Take the intercity train to Brussels North Station. Change to Antwerp Station. Change to Mol railway Station. *(indicative rate: € 15)* (app. 2h total travel time)

For more information please check the website of the Belgian Railways: www.b-rail.be

Accommodation

The course is organised in residential form. Dormitories or hotelrooms on SCK•CEN domain are available.

- Dormitories without hotel service (only sheets, no cleaning) € 76,95 for 2 weeks
- Dormitories with hotel service: towels, soap, cleaning € 263,47 for 2 weeks
- Club-House hotel (breakfast included)

  single: € 50 /night double: € 70 /night

SCK•CEN guarantees 10 dormitories on a "first come, first served" base. Deadline for registration is December 13, 2004.

For all reservations of dormitories, a cash warranty of € 135 must be payed upon arrival.

Meals

Meals can be taken at the

- cafeteria (self service) (lunch from € 4)
- the Club-House restaurant (lunch/dinner from € 10)
- the pub of the sportsclub (snack from € 2)
- the dormitory building has a communal kitchen

Course on
Nuclear Reactor Theory

Mol, Belgium, Jan. 12 – 29, 2005

Organised by BNEN:

BNEN is a consortium of the Belgian universities

- *Katholieke Universiteit Leuven,*
- *Université Catholique de Louvain,*
- *Université de Liège,*
- *Universiteit Gent,*
- *Vrije Universiteit Brussel*,

in collaboration with SCK•CEN, the Belgian Nuclear Research Centre
www.sckcen.be/BNEN

BNEN courses are proffered within the ENEN association. ENEN is a non-profit organisation to preserve and develop higher nuclear education and expertise

www.enen-assoc.org

Introduction – Scope of the Course

The main objectives of the "Nuclear Reactor Theory" course are:

- To understand physical processes involved in a nuclear reactor
- To understand and solve basic equations governing nuclear reactors
- To gain insight in experimental techniques to determine the various reactor parameters

The course comprises three parts of reactor theory and three laboratory sessions. Each theory session is about 2 hours of lectures, each lab session takes half a day.

The following text books are used as references:

John R. Lamarsh, "Introduction to Nuclear Reactor Theory", Addison-Wesley, Reading, Massachusetts, 1972.

James J. Duderstadt & Louis J. Hamilton, "Nuclear Reactor Physics", Wiley, New York, 1976.

Programme

Nuclear Reactor Theory Part I (Prof. W. D'haeseleer)

- Review of Nuclear Physics; Interaction of Neutrons with Matter.
- Nuclear Fission; Nuclear Chain-Reacting systems; Diffusion of Neutrons
- Diffusion of Neutrons: continued; Neutron Moderation without Absorption
- Exercises

Nuclear Reactor Theory Part II (Prof. J.-M. Noterdaeme)

- Neutron Moderation with Absorption and Fission
- Low Energy Neutrons
- Fermi Theory of the Bare Thermal Reactor
- Multiregion Reactors, The Group Diffusion Method
- Multiregion Reactors, The Multigroup Diffusion
- Exercises

Nuclear Reactor Theory Part III (Prof. E. Mund)

- Transport Theory
- The Diffusion Approximation Revisited
- Perturbation Theory
- Nuclear Reactor Kinetics
- Heterogeneous Reactors
- Changes in Reactivity; Exercises

Laboratory sessions (Prof. P. Baeten)

Sigma Pile

The purpose of this laboratory session is the determination of the basic static reactor parameters: the diffusion length, the diffusion coefficient and the Fermi-age of a graphite moderator at the Sigma Pile. The obtained results will be discussed in view of the applied methods. Meanwhile the students will be familiarized with the main principles of slow neutron detection.

VENUS Reactor

The purpose of this laboratory session is the determination of the axial fission-rate distribution of a pure UO2 critical configuration at the VENUS critical facility. From this axial fission-rate distribution, the axial buckling of the core together with the mean reflector savings can be determined. During the experiment, the correct settings of the electronic measurement will be verified. The measured parameters results will be compared with analytical calculations and hence the obtained results will be discussed.

BR1 Reactor

Subcritical approach of the BR1 reactor: the criticality of the reactor is determined by estimating the critical height of the control rods by successive measurements and verification of the estimated height and the actual critical height.

Period measurement and control rod worth: both positive and negative reactor periods are evaluated and the reactivity worth of the control rods is calculated.

Reactor kinetics: the position of the control rods is subject to a specific profile, and the corresponding reactor power is recorded and compared with the theoretical calculation.

Examination

A written examination, prepared by the course staff, is foreseen on June 6, 2005; 08.30 – 12.30.

Course credit

The course is rated 8 ECTS within the Belgian interuniversity programme for Master of Science in Nuclear Engineering (BNEN)

Lecturers

William D'haeseleer is full professor at the University of Leuven (K.U.Leuven). He presently teaches courses in the domains of Nuclear Engineering, Energy Management and Applied Thermodynamics & Energy Conversion.
His research activities concentrate on energy systems, energy management and energy policy.

Ernest Mund is professor of Nuclear Engineering at the Université Catholique de Louvain (UCL – Louvain-la-Neuve) and research director at the Fonds National de la Recherche Scientifique.
His research activities concentrate on nuclear reactor theory, computational methods in particle transport problems, numerical methods and risk analysis.

Jean-Marie Noterdaeme is professor of Nuclear Engineering at the Universiteit Gent and deputy group leader at the Max Planck Institut für Plasmaphysik.
His research concentrates on heating and control of thermonuclear plasmas with electromagnetic waves.

Peter Baeten is professor of Nuclear Engineering at the Vrije Universiteit Brussel and operating head of the BR1 reseach reactor and the VENUS critical facility at SCK•CEN, the Belgian Nuclear Research Centre.