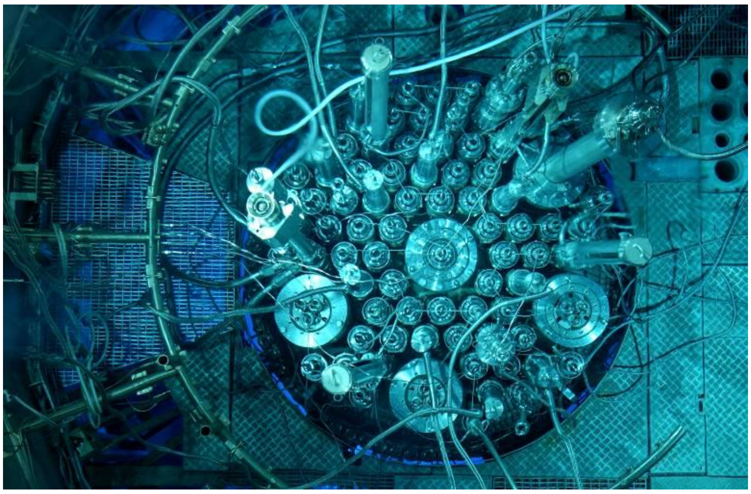
BNEN

BELGIAN NUCLEAR HIGHER EDUCATION NETWORK (BNEN)

Interuniversity programme in Nuclear Engineering

Your way to the European Master in Nuclear Engineering!



UNIVERSITEIT GENT | Université de Liège | UCL Université catholique de Louvain | SCK•CEN | ULB | Vrije Universiteit Brussel | KU LEUVEN

Contact

BNEN
SCK•CEN
Boeretang 200
BE-2400 MOL
+32 14 33 21 48
bnen@sckcen.be

SCK•CEN (Registered Office)
Avenue Herrmann-Debroux 40
BE-1160 BRUSSELS

Responsible editor
Nele Kesteloot
Administration Manager BNEN
SCK•CEN
Boeretang 200
BE-2400 MOL
+32 14 33 21 43
nele.kesteloot@sckcen.be

Courses and Laboratories BNEN
SCK•CEN
Boeretang 200
BE-2400 MOL
+ 32 14 33 21 48

http://www.sckcen.be/BNEN

BNEN is an active member of ENEN,
the European Nuclear higher Education Network
http://www.enen-assoc.org

TABLE OF CONTENTS

Introduction	**1**
Steering Committee	**3**
BNEN Courses	**5**
BNEN Admission Criteria	**7**
General Information	**10**
Application process	10
Academic Calendar	10
ECTS Credits	11
Exemptions	12
Laboratory session	12
Quality	13
Costs	13
Communication	13
Master Thesis / Internship	**14**
Grants	**16**
Deliberation Rules	**17**
Registration Form	**20**
Annex: Presentation of BNEN Courses and Teaching Staff	**22**

INTRODUCTION

BNEN, the Belgian Nuclear higher Education Network has been created in 2001 by five Belgian universities and the Belgian Nuclear Research Centre (SCK•CEN) as a joint effort to maintain and further develop a high quality programme in nuclear engineering in Belgium. The current consortium was established in 2006 when the sixth partner university joined the programme. In a country where a substantial part of the electricity generation will remain of nuclear origin for a number of years, there is a need for well-educated and well trained engineers in this area. Public authorities, regulators and industry brought their support to this initiative. In the framework of the new architecture of higher education in Europe, the English name for this 60 ECTS programme is “Master of Science in Nuclear Engineering”. To be admitted to this programme, students must already hold a university degree in engineering or equivalent. For students not fully satisfying this requirement, special entrance consideration applies as explained further in the brochure.

During the preparation of this “master after master” programme, all partners agreed to strive for top quality goals. Linked with university research, benefiting from the human resources and infrastructure of SCK•CEN, encouraged and supported by the partners of the nuclear sector, this programme should be offered not only to Belgian students, but also more widely throughout Europe and the world. This is why parallel efforts were made to create a European network of academic institutions active in nuclear engineering education, to establish links with the International Atomic Energy Agency (IAEA), with the Nuclear Energy Agency of the OECD (NEA), and other international bodies like the World Nuclear University (WNU).

Today, the European network has been established as an international association of about fifty universities cooperating with the European stakeholders (industry, regulators, research centres), and is strongly supported by the European Commission. Its name is ENEN (European Nuclear Education Network). It is legally based at the premises of the "Institut National Supérieur des Sciences et Techniques Nucléaires" (INSTN) at Saclay, and BNEN is the Belgian pole of this network. Students registering to any of the participating institutions are offered the opportunity to coherently take a part of their basic nuclear education at different places in Europe while cumulating credit units. Practical laboratory sessions and advanced subjects taught in a modular way are also offered to enrich the programmes. A special qualification of “European master” is awarded to the students who have obtained their degree with a substantial effort of mobility. The ENEN Association is taking care of the quality of the programmes including their professional relevance, the links with the research world and with the practical training organisations.

Thanks to ENEN, several courses organised by the BNEN consortium are taken by a significant number of foreign students. Their presence gives our lectures an international atmosphere of friendship and competition. The master programme is a demanding programme where students with different high level backgrounds in engineering have to go through highly theoretical subjects like neutron physics, fluid flow and heat transfer modelling, and apply them to reactor design, nuclear safety and plant operation & control. As a more interdisciplinary level, the programme includes some important chapters of material science, with a particular interest for the fuel cycle. Radiation protection also belongs to the backbone of the programme. All subjects are taught by academics appointed by the partner universities, whereas the practical exercises and laboratory sessions are supervised by researchers of SCK•CEN. The final thesis offers an opportunity for internship in industry or in a research laboratory.

The programme structure includes the possibility to spread it over two years, especially to accommodate young engineers working already in the nuclear sector. All students are strongly encouraged to include a period of training abroad, to benefit from the multiple opportunities created by ENEN.

We are conscious that this challenging programme will be able to deliver a considerable number of highly qualified engineers required for the safe and economic operation of the nuclear power plants, not only in Belgium, but also in the world.

Prof. Dr. ir. Michel GIOT

Chairman of BNEN 2002 - 2004

BNEN STEERING COMMITTEE

For the academic years 2014-2015 / 2015-2016

Université Catholique de Louvain

Prof. Yann Bartosiewicz — Proxy: Prof. Hamid Aït Abderrahim
Chairman
Yann.Bartosiewicz@uclouvain.be — hamid.ait.abderrahim@sckcen.be

KU Leuven

Prof. William D'haeseleer — Proxy: Prof. Walter Bogaerts
Vice-Chairman
william.dhaeseleer@mech.kuleuven.be — walter.bogaerts@mtm.kuleuven.be

Universiteit Gent

Prof. Jean-Marie Noterdaeme — Proxy: Prof. Klaus Bacher
jmn@ipp.mpg.de — klaus.bacher@ugent.be

Vrije Universiteit Brussel

Prof. Peter Baeten — Proxy: Prof. Alex Hermanne
peter.baeten@sckcen.be — aherman@vucy.vub.ac.be

Université de Liège

Prof. Jacqueline Lecomte-Beckers — Proxy: Prof. Pierre Van Iseghem
jacqueline.lecomte@ulg.ac.be — pviseghe@sckcen.be

Université Libre de Bruxelles

Prof. Pierre-Etienne Labeau — Proxy: Prof. Alain Dubus
pelabeau@ulb.ac.be — adubus@ulb.ac.be

Belgian Nuclear Research Centre (SCK•CEN)

Prof. Eric van Walle — Proxy: Dr. Nele Kesteloot
General manager SCK•CEN — Administration Manager
eric.van.walle@sckcen.be — nele.kesteloot@sckcen.be

Ms. Kris Pennemans
Secretary
bnen@sckcen.be
http://www.sckcen.be/BNEN

BNEN SHARE OF TEACHING RESPONSIBILITIES

	ECTS	KU Leuven	UGent	VUB	UCL	ULB	ULg	Titular
Compulsory modules	**31**							
Introduction to nuclear energy	3	3						William D'HAESELEER André POUCET
Introduction to nuclear physics and nuclear measurements	3					3		Nicolas PAULY Alain DUBUS
Nuclear materials	3	2					1	Jacqueline LECOMTE-BECKERS Walter BOGAERTS Eric VAN WALLE
Nuclear fuel cycle	3						3	Hubert DRUENNE Pierre VAN ISEGHEM
Radiation protection	3		3					Hubert THIERENS Klaus BACHER
Nuclear thermal hydraulics	5				5			Yann BARTOSIEWICZ
Nuclear reactor theory	6	2	2	2				William D'HAESELEER Jean-Marie NOTERDAEME Peter BAETEN
Safety of nuclear power plants	5		3			2		Hubert DRUENNE Pierre-Etienne LABEAU Greet JANSSENS-MAENHOUT André POUCET
Elective modules (9ECTS to be chosen from the list below)	**9**							
Advanced nuclear reactor physics and technology	3				3			Hamid Aït ABDERRAHIM
Advanced nuclear materials	3	2					1	Walter BOGAERTS Jacqueline LECOMTE-BECKERS Eric VAN WALLE
Advanced radiation protection radiation ecology	3		3					Klaus BACHER
Advanced courses of the nuclear fuel cycle	3						3	Hubert DRUENNE Pierre VAN ISEGHEM
Nuclear and radiological risk governance	3		1		2			Frank HARDEMAN Greet JANSSENS-MAENHOUT
Advanced course elective topic	3			3				Peter BAETEN
Master thesis	**20**							
Total	**60**							

BNEN ADMISSION CRITERIA

This BNEN programme is open for students:

1. On the basis of their diploma: students holding a 5-year Master degree in Engineering (any orientation except engineer-architect) from a Belgian University:
   - “Burgerlijk ingenieur” and “Bio-ingenieur” from the Flemish Community (Master in Engineering Sciences)
   - “Ingénieur civil” and “Bio-Ingénieur” from the French Community
   - “Burgerlijk Ingenieur Polytechnicus” from the “Koninklijke Militaire School” at Brussels
   - “Ingénieur Civil Polytechnique” from the “Ecole Royale Militaire” at Brussels.

2. On the basis of a decision by the Teaching Committee based on the evaluation of a dossier (previous studies and experience), complemented by successfully passing a bridge programme: Candidates holding a Master in Engineering of non-university institutes for higher education (“Industrial Engineers”) and Master in Sciences (i.e. Master in de wetenschappen, Master en Sciences, 4 year Master in Engineering,…).

3. Candidates holding a foreign degree of higher education can be admitted within the limits stipulated by the above mentioned Decrees, after evaluation and approval of the Teaching Committee and with observance of the procedural rules of the respective participating universities.

BNEN "entrance-exam" scope for 4 year Master in Engineering and Master in Sciences

The students are encouraged to follow a set of courses at the university of her/his choice (in principle covering the study of 30 ECTS points) as approved by the Teaching Committee of BNEN, and take the exams. Upon successfully passing the exams, the student will be admitted to the BNEN programme.
Depending on the university chosen and on the student background, the make-up courses may be different. Hereunder, an example for the KU Leuven is given. As a guideline, the “bridge year” followed by an industrial engineer to obtain the master in engineering is taken as a basis. However, some freedom of choice should/may be built in.
For the KU Leuven the choice is as follows.

Bridge programme BNEN at KU Leuven

All (basic bachelor) courses are taught in Dutch, but lecturers will assign a good English textbook (which covers the same material as in their own courses) and examine the students *in English. Non-Dutch speaking students must contact the instructors by mail to set up an appointment or to make arrangements by mail or phone.*

Programme for students with engineering background (foreign students & "Industrial Engineers" from Belgian University Colleges)

1. H08W4A (3 ECTS - W. D'haeseleer)
Fluid Mechanics / Fluidummechanica
http://onderwijsaanbod.kuleuven.be/syllabi/n/H08W4AN.htm

2. H08W5A (3 ECTS – E. Van den Bulck)
Heat Transfer / Warmteoverdracht
http://onderwijsaanbod.kuleuven.be/syllabi/n/H08W5AN.htm

3. H01N2A (6 ECTS – M. Baelmans)
Energy Conversion Machines and Systems / Energieconversiemachines en systemen
http://www.kuleuven.ac.be/onderwijs/aanbod/syllabi/H01N2AN.htm

4. H0M71A (5 + 1 ECTS) M. Van Barel
Numerical Mathematics / Numerieke wiskunde
http://www.kuleuven.ac.be/onderwijs/aanbod/syllabi/H0M71AN.htm

5. H0M69A (6 ECTS – R. Cools)
Applied Algebra and Differential Equations / Toegepaste algebra en differentiaalvergelijkingen
http://www.kuleuven.ac.be/onderwijs/aanbod/syllabi/H0M69AN.htm

6. H01M8A (6 ECTS – B. De Moor)
System Theory and Control Theory / Systeemtheorie en regeltechniek
http://www.kuleuven.ac.be/onderwijs/aanbod/syllabi/H01M8AN.htm

For course nr 4; the formal load is 5 ECTS; but the professor will give an extra assignment (being an effort of 1 ECTS) to make it a logical total of 30 ECTS so as to satisfy the BNEN requirements.

Programme for students with a background in physics, mathematics or chemistry

1. H01L8A (6 ECTS – R. Belmans)
Electrical Energy and Drives / Elektrische Energie en aandrijvingen
http://www.kuleuven.be/onderwijs/aanbod/syllabi/H01L8AN.htm

2. H08W4A (3 ECTS - W. D'haeseleer)
Fluid Mechanics / Fluidummechanica
http://onderwijsaanbod.kuleuven.be/syllabi/n/H08W4AN.htm

3. H08W5A (3 ECTS – E. Van den Bulck)
Heat Transfer / Warmteoverdracht
http://onderwijsaanbod.kuleuven.be/syllabi/n/H08W5AN.htm

4. H01N2A (6 ECTS – M. Baelmans)
Energy Conversion Machines and Systems / Energieconversiemachines en systemen
http://www.kuleuven.ac.be/onderwijs/aanbod/syllabi/H01N2AN.htm

5. H01M8AN (6 ECTS – B. De Moor)
System Theory and Control Theory / Systeemtheorie en regeltechniek
http://www.kuleuven.ac.be/onderwijs/aanbod/syllabi/H01M8AN.htm

6. H9XA1A (3 ECTS – J. Van Humbeeck)
Construction Materials / Constructiematerialen
http://www.kuleuven.be/onderwijs/aanbod/syllabi/H9XA1AN.htm

7. H01D0A (E ECTS – A. Verlinden)
Introduction to Material Science / Inleiding tot de materiaalkunde
http://www.kuleuven.be/onderwijs/aanbod/syllabi/H01D0AN.htm

For a list of reference books on BNEN prerequisites: http://www.sckcen.be/BNEN

GENERAL INFORMATION

Application process

STEP 1: Acceptance by the BNEN Teaching Committee

An application file consists of, at least:

- the registration form;
- a motivated application letter;
- a curriculum vitae;
- transcripts of academic results;
- when applying for a grant, a declaration of the non-employment situation (limited number of grants)

STEP 2: Registration in one of the six partner universities

After approval by the Teaching Committee students need to register at one of the six universities.

Pay attention to all the registration procedures at your university. There can be problems when you want to spread the programme over more than 1 year. The processes at the Flemish universities are different than the ones at the French speaking side of the country. For more information, contact the administration department of the university of your choice.

STEP 3: Access to the Belgian Nuclear Research Centre

All candidates will be screened by the Belgian Federal Agency for Nuclear Control for clearance and access to the nuclear infrastructure of SCK•CEN. Admission to the programme will depend on clearance and access being granted.

BNEN Academic Calendar

- Start: End of September
- 24 weeks of courses
- 11 weeks for project work and examinations

For a detailed calendar: consult http://www.sckcen.be/BNEN

What are ECTS credits?

ECTS credits are a value allocated to course units to describe the average student workload required to complete them successfully. They reflect the quantity of work each course requires in relation to the total quantity of work required to complete a full year of academic study at the institution, that is, lectures, practical work, seminars, private work – in the laboratory, library or at home – and examinations and other assessment activities.

In ECTS, 60 credits represent one year of study (in terms of workload); normally 30 credits are given for six months (a semester) and 20 credits for a term (a trimester).

ECTS credits are also allocated to practical placements and to thesis preparation when these activities form part of the regular programme of study at both the home and host institutions.

ECTS credits are allocated to courses and are awarded to students who successfully complete those courses by passing the examinations or other assessments.

Ref.: http://ec.europa.eu/education/ects/ects_en.htm

How to translate ECTS in work load - hours?

60 ECTS – 1 year workload or 40 weeks x 45 hours/week = 1 800 hours.

3 ECTS credits represent an estimated workload of 90 hours for the student.

Typically 3 ECTS = 1 teaching module = 20 hours of lectures + 10 hours e.l.s.

e.l.s. = exercises, laboratory sessions, seminars.

For a 3-ECTS course, these 90 hours might be rated as:

- 20 hours lectures x 3.5 = 70 hours. The factor 3.5 is applied as the standard student needs another 2.5 hours to assimilate what has been taught in one hour. This factor also depends on the teaching pace. Some universities foresee more contact hours and integrate more examples/exercises and apply a factor of 2.5 or 3.
- 10 hours els x 1.5 = 15 hours. Laboratory sessions and/or exercises, without too much of reporting, get a factor 1. With reporting: 1.5.
- 5 hours additional independent reading/study.
- In summary: 70 hours + 15 hours + 5 hours = 90 hours.

A different 3-ECTS course might be rated as:

- 20 hours lectures x 4 = 80 hours
- 10 hours els x 1 = 10 hours
- In summary: 80 hours + 10 hours = 90 hours.

An elective/advanced course e.g. a topical day of 1 ECTS or 30 hours:

- 8 hours lectures x 1.5 = 12 hours
- 12 hours report preparation = 12 hours
- 6 hours report writing = 6 hours
- In summary: 12 hours + 12 hours + 6 hours = 30 hours
- Remark: reports of 10 to 20 pages, to be handed in six weeks after the event.

Exemptions

Students can ask for an exemption for a particular course or a part of the course. This request should be submitted in time to the BNEN Steering Committee.

Prior to a formal positive decision from the Steering Committee concerning the requested exemption, students must assume they have to take the course(s).

Note that a maximum of 6 ECTS (credits) can be accepted.

BNEN Laboratory sessions

- Most courses include exercises, laboratory sessions and/or seminars (els).
- **Attendance to exercises, laboratory sessions, seminars is compulsory** (2nd teaching committee meeting dd. October 22, 2002). It is strongly recommended to take the els with the course. However in case of motivated "non-possimus", an els attendance might be shifted to another occasion a.o. to the next year.
- The academic responsible for the course decides on the reporting (number of pages, deadline) as well as on the weight of the els in the final quotation of the overall course.

Quality

Quality Assurance (QA) has been emphasized from the beginning in this interuniversity programme. Both the programme as a whole and the different courses individually have been and are being evaluated on a regular basis. For the QA aspect of curriculum and programme monitoring, the BNEN Steering Committee plays the leading and a nearly independent role. The BNEN tools for evaluations and QA exist on top of the QA policy of the individual universities and of SCK•CEN.

QA is an fixed agenda point on each Steering Committee meeting. The BNEN vice-chairman is appointed as QA responsible for the programme. The BNEN Administration Manager acts as Ombudsperson.

Costs

Full time students pay the enrolment fee at the university where they register for the programme.

The fee of part time students (being those spreading the programme over more than one year) depends on the credits they register for at the university.

For continuous professional development programmes, please contact the secretariat.

Communication

Most correspondence concerning the programme goes through the BNEN secretariat (bnen@sckcen.be). However we would also like to ask our students to check their e-mail account of the university on a regular basis.

BNEN MASTER THESIS – PROJECT WORK/INTERNSHIP

General

- The master thesis is an essential part of the post-graduate programme for Master of Science in Nuclear Engineering.
- The master thesis is rated about 33% of the students workload or about 13 to 14 weeks.
- Students are reminded to have regular contacts, not only with their mentor, but also with their academic promoter, all along the thesis project.
- For more details consult the thesis guidelines in the restricted area of the BNEN website.

Proposing a thesis subject

- By mid-November, students have to submit to the teaching committee a thesis proposal, presenting the context, objectives, methodology and expected results of their work, and mentioning the academic promoter (if already known) and the mentor(s) proposed.
- Young professionals can propose a subject in their company, provided the work is significantly different from their daily duties and is performed in the perspective of an academic work.
- During the teaching committee meeting scheduled mid-November, the proposals are discussed. Complements of information or adaptations can be asked to the students, before accepting the proposal. The teaching committee designates for each student the thesis jury, composed of the promoter and (at least) two assessors. At least one of the thesis jury members should belong to the university where the student has registered.

Submitting the thesis

- Students are not allowed to defend their master thesis before **the promoter has signed the thesis abstract page** (see BNEN website, Thesis section). For this purpose, a preliminary version of the thesis must be made available to the promoter, **4 weeks** before the presentation at the latest.
- Once the thesis work has been approved for defense by the promoter, a complete **paper version** of the thesis report must be made available to all jury members **2 weeks** before the presentation at the latest.

- The strict respect of these procedure and guidelines conditions the authorization to present the thesis. In case they are not respected, the presentation of the thesis will automatically be postponed to the next session.

Plagiarism

- Plagiarism is the act of using any part (text, graphs, pictures…) of a written document authored by a third party, without properly referencing it.

- Students guilty of plagiarism in any course report or in the thesis report of their BNEN programme put themselves at the risk of penalties, which can range from a nil mark for the concerned course to an adjournment.

Prizes on final year thesis (for information only)

- SCK•CEN annually allots a prize of € 1500 to the best university thesis carried out in its laboratories. http://www.sckcen.be

- The Belgian Nuclear Society – Young Generation allots prizes of up to more than €1500 to a thesis or paper in the field of nuclear sciences. http://www.bnsorg.be

- The Belgian Physical Society annually awards three scientific prizes, € 250 each, to reward the best master thesis in the field of physics. http://www.belgianphysicalsociety.be

GRANTS

The grants are called BNEN grants, or possibly BNEN-XXXX grant, where XXXX stands for the sponsoring company.

Selection

- Grants are awarded based on a selection made by the BNEN steering committee.
- Ranking is according to the best academic results.

Admission criteria

- Enrolment for the interuniversity programme in Nuclear Engineering at a BNEN university (KU Leuven, UCL, UGent, ULiège, VUB, ULB).
- Applicants are available full time for the studies (60 ECTS in one academic year).
- Or at least half time (60 ECTS spread over two academic years), no grant in case of failure for the next year.
- Students with a full-time employment are not eligible for the grant.
- Applications have to be sent to the BNEN administration before August 1.

Application file

An application file consists of, at least:

- A motivated application for a grant
- A curriculum vitae
- Transcripts of academic results
- Evidence of enrolment for the interuniversity programme in Nuclear Engineering
- A declaration on the (non-) employment situation

Grants

- Depending on the BNEN financial reach, up to three BNEN grants a year might be given.
- The gross grant amounts to € 10.000.
- Due to administrative reasons, grant instalment may be rather late in the academic year (the objective: January 15: first payment, April 15: second payment).

Advice

Applicants are advised to consult a BNEN professor at their university as soon as possible.

DELIBERATION RULES

Common criteria for passing course units and for succeeding the BNEN year of study:

Article 1 (criteria for passing course units)

A student shall be deemed to have succeeded in a course unit if **at least 10 out of 20 points** or a 'pass' assessment has been awarded.
In both cases a **credit certificate** shall be delivered to the student, unless the enrolment fee was not paid on time or fraud has been established.

Article 2 (weighting)

In order to establish the **percentage** obtained for the BNEN year of study, the individual course results are weighted by the number of ECTS characteristic of that course and/or master project work or thesis.
The BNEN Teaching Committee, at its discretion, can decide to adjust or modify the ECTS allocation of the particular courses and master project work or thesis in general, or for individual students in case those students request credit transfer from earlier course work or from exchange courses. If changes have occurred compared to the previous year, the new arrangement shall be made public at the start of the academic year.
The course units that are only assessed by means of the 'pass/no pass' system are excluded from the calculation of the (weighted or unweighted) percentage.

Article 3 (criteria for succeeding the BNEN year of study)

All courses are graded with marks out of 20; i.e., each result is expressed as x/20 with 0. le. x .le. 20. A grade less than 10/20 is referred to as a 'failing grade'.

Definition:
For each failing grade for a course, the number of 'fail points' is defined as the number of points below 10/20. E.g., a score of 08/20 amounts to two 'fail points'.
If applicable, the number of 'fail points' for several courses is added together to obtain the total number of 'fail points'. E.g., a score of 08/20 for one course and 09/20 for another course amounts to three 'fail points'.

A student shall be deemed to have passed the complete BNEN year of study when one of the following two conditions has been met:

a) S/he has passed all courses of the year of study (10/20 or 'pass'); i.e., a **percentage of 50%** suffices if all courses have been passed successfully.

b) In case of course failure (other than the master thesis/project), a maximum of two scores of 09/20 can be 'pardoned' by the Examination Board, on the condition that every 'fail point'

is 'overcompensated' by 2 %-pts in the average percentage score. This means that the Examination Board is willing to award the degree even in the following cases:
student has one 09/20 but at least 52 % on average;
student has two 09/20 but at least 54 % on average.

c) In case of course failure (other than the master thesis/project), a maximum of one score of 08/20 can be 'pardoned' by the Examination Board, on the condition that every 'fail point' is 'overcompensated' by 2 %-pts in the average percentage score. This means that the Examination Board is willing to award the degree even in the following case:
student has one 08/20 but at least 54 % on average.

d) As a rule, in case of a total of more than 2 'fail points' (i.e., the accumulation of all marks short of 10), students will not be 'pardoned'.

e) For the master project/thesis a minimum score of 10/20 is always required.

In exceptional circumstances the Examination Board may decide to award a pass to a student who failed to meet the criteria set forth in the present examination regulation. Each member of the Examination Board or the ombudsperson may request a secret vote. If the Examination Board decides (whether by secret vote or not) to award a pass to the student in such a case, it shall justify its decision by citing the special circumstances that prompted the decision.

In the case of students who follow a part-time or personalized itinerary arranged according to a programme of several study years, the Examination Board shall only take a decision on whether a student has passed or succeeded if the latter has obtained results for all the course units of one year of study.

For students not satisfying the requirements to pass as laid down in this Article 3, the decision will be recorded as '*adjourned*', except for an incomplete submission as explained in Article 4.

Article 4 (special examination board decisions)

The BNEN examination board may establish that a student:

- is guilty of irregular conduct and decide to impose one of the sanctions as described in the examination regulation of the university of registration.

- has not participated in all exams and has therefore submitted an **incomplete result**, in which case a decision is made to postpone a final judgement on said student. On the transcript, the decision will be recorded as '*incomplete*'.

Article 5 (criteria to obtain a Master's degree and levels of achievement)

The student who has passed the BNEN year of study obtains the degree of Master in Nuclear Engineering.
Students who have a reduced study load and whose programme of study is divided differently in time, shall obtain the degree of Master when they have passed each of the course units of their programme of study, albeit taking into account the conditions set out in Article 3.

A student obtaining the degree of Master shall be awarded with the following levels of achievement:

- *satisfaction* (cum fructum), if the student passes according to the rules laid down in Article 3;

- *distinction* (cum laude), on condition that 68% of the marks have been obtained and that all course units received a mark of at least 10/20;

- *great distinction* (magna cum laude), on condition that 77% of the marks have been obtained and that all course units received a mark of at least 10/20;

- *greatest distinction* (summa cum laude), on condition that 86% of the marks have been obtained and that all course units received a mark of at least 10/20;

- *greatest distinction* (summa cum laude) *with the congratulations of Examination Board*, on condition that 90% of the marks have been obtained and that all course units received a mark of at least 10/20.

For each 9/20 or in case of an 8/20; two and four percentage points, respectively, are added to the above mentioned requirements for levels of achievement. The mention "Congratulations" can not be awarded if there are marks below 10/20.

William D'haeseleer
September 30, 2006

Accepted by the BNEN Steering Committee Meeting nr. 28

BNEN

Belgian Nuclear higher Education Network

ID Picture

Academic Year 2015 - 2016

☐ ***Unique year*** ☐ ***Unique year bis*** ☐ ***Part I*** ☐ ***Part I bis*** ☐ ***Part II*** ☐ ***Part II bis***

Registration form

TO SEND BACK NOT LATER THAN AUGUST 1, 2015
Please complete this form and send it to
Nele Kesteloot/ Kris Pennemans:

SCK•CEN, Boeretang 200, B-2400 Mol,
E-mail: bnen@sckcen.be

APPLICANTS DATA

Private data

Last Name: _____ **First Name:** _____ ❑ **Prof.** ❑ **Dr.** ❑ **Mr.** ❑ **Ms.**

Private address: _____

Zip: _____ **Town:** _____ **Country:** _____

Place of birth: _____ **Date of birth:** _____ **Nationality:**_

Passportnumber: _____ **Date of Issue:** _____ **Valid till:** _____

National register no.:_____________

Professional data

Company: _____ **Address:** __________________________________

Position at company:________________

Zip: _____ **Town:** _____ **Country:** _____

Phone: _____ **Fax:** _____ **E-mail:** _____

University in which you intend to enroll

○ **K.U.Leuven** ○ **UCL** ○ **ULg** ○ **UGent** ○ **VUB** ○ **ULB**

✍ ***Please use capitals.***

Hereby I apply for registration in the BNEN "Belgian Nuclear higher Education Network". I accept that my application is subject of a selection procedure, and may be refused, if the steering committee decides so, due to any reason. I understand that my travels to Mol (Belgium) and back, my accommodation, my insurances, and the acquisition of the necessary visa have to be arranged and paid individually if I will be selected for participation.

The following documents are attached to my application:
1) A Curriculum Vitae (English knowledge must be stated).
2) A list of courses followed during the university studies. A short description of the content of the following courses: mathematics and physics.
3) A statement about the way of the coverage of the costs of my participation (own sources, home university, grant, fellowship, etc.).
4) A copy of your degree(s).
5) We advise students to provide us a GRE (Graduate Record Evaluation) score. It will help us to make a decision about your application.
6) Proof of registration at the university

Date: Signature: N/A (electronic)

After signing this document the candidate acknowledges that:

- *After acceptance of the application by the BNEN Steering Committee, the candidate is authorised to enrol at one of the partner universities for the 'Master of Nuclear Engineering' (KULeuven, UGent, VUB) or for the 'Master Complémentaire en Génie Nucléaire' (UCL, ULg, ULB).*
- *The acceptance notification only is not sufficient for non-EU candidates to apply for a student visa. Proof of registration in one of the partner universities is needed.*
- *Registration for isolated courses only is not sufficient for non-EU candidates to apply for a student visa.*

Annex

Presentation of compulsory BNEN Courses

Introduction to Nuclear Energy

BNEN

Prof. William D'haeseleer – Katholieke Universiteit Leuven (KU Leuven)

3 ECTS 84 hours study time	20 contact hours theory
	8 contact hours seminars (exersises/laboratory sessions/visits)
	0 contact hours extra personal work

Learning Outcomes

- To give a first overview of nuclear electricity generation and an overall introduction to reactor and plant engineering
- To place the world and the Belgian nuclear energy production in its economic, social, technical and cultural context

Content

- Elementary aspects (first acquaintance) with practical nuclear physics and interaction of radiation with matter.
- Birds-eye view of nuclear power generation: principle of generating electricity by nuclear means (fission; chain reaction; heat transfer to coolant; turbine; alternator); fissile & fertile materials; burn up; production of fission products; breeding; current types of power plants (PWR, BWR,…); future types of power plants (LWR-type, gas cooled, ADS, …); introduction to the fuel cycle; front end, back end; introduction to safety aspects of nuclear reactors (criticality; core melt); engineered safety systems; risk; difference with research reactors & fusion reactors; proliferation issues & safeguards
- Economics of nuclear power generation: cost of nuclear kWh; investment costs of new types NPP's; construction time; decommissioning costs; internalisation of waste management; external costs
- Compatibility of nuclear power generation with sustainable development. Public perception & communication (media, general public, public authorities).

Course Material and Reference Books

Textbook followed:

- John R. Lamarsh & Anthony J. Baratta, "Introduction to Nuclear Engineering"; 3-rd Ed., Prentice Hall, Upper Saddle River, NJ, 2001 (ISBN 0-201-82498-1)

Other interesting books:

- Ronald Allen Knief, "Nuclear Engineering; Theory and Technology of Commercial Nucler Power"; 2-nd Ed., Taylor & Francis, Washington DC, 1992 (ISBN 1-56032-089-3)

- David Bodansky, "Nuclear Energy; Principles, Practices, and Prospects"; 2-nd Ed., Springer, Berlin/New York, 2004 (ISBN 0-387-20778-3)

PRE-ASSUMED KNOWLEDGE OR PREREQUISITES

Students are supposed to have a solid knowledge in basis engineering sciences such as thermodynamics, fluid mechanics, heat transfer, material science etc. (Level of electro-mechanical university graduated engineers is optimal.

GRADING AND EXAMINATION

Open book preparation of two or three (generally overview) questions. Students can take notes during the 30 min preparation. Students will then be interrogated orally (whereby they can use the just made notes if they wish) to check whether they have thoroughly understood the study material. Questions are oriented towards understanding and insight; marks are given for the performance during the oral examination (lasting 30 mins); not for the written preparation.

Introduction to Nuclear Physics and Measurements

BNEN

Prof. Nicolas Pauly – Université libre de Bruxelles
Prof. Alain Dubus – Université libre de Bruxelles

3 ECTS 90 hours study time	24 contact hours theory
	6 contact hours exercises/laboratory sessions/visits
	0 contact hours personal work

Learning Outcomes

- To learn and understand the basic properties of a nucleus
- To understand the role of conservation laws in decay processes and reactions
- To learn particles interactions with matter
- To learn characteristics of main particles detectors

Content

- Nuclear properties (nuclear radius; mass and abundance of nuclides; nuclear binding energy; nuclear exited states)
- Radioactive decay law, radioactive chains, units of radioactivity
- Alpha, Beta and Gamma decay
- Nuclear fission
- Types of nuclear reactions: compound nucleus, threshold reactions, concept of cross section
- Interactions of ionizing radiations (ions, electrons, photons, neutrons) with matter
- Detection of ionizing radiations (ions, electrons, photons, neutrons)

Course material and reference books

The PowerPoint presentation of the lectures is available on the BNEN website.

Other useful references:

Krane, K.S. "Introductory Nuclear Physics", Wiley, 1987.

Tavernier, S. "Experimental techniques in nuclear and particle physics", Springer-Verlag, 2010.

Knoll, G.F. "Radiation detection and measurement", 4 ed., Wiley, 2010.

Pre-assumed knowledge or prerequisites

Bachelor level lectures on physics, mechanics, mathematics.

GRADING AND EXAMINATION

Written examination (closed book).

Nuclear Materials

Prof. Jacqueline Lecomte-Beckers – Université de Liège
Prof. Eric van Walle – Katholieke Universiteit Leuven
Prof. Walter Bogaerts - Katholieke Universiteit Leuven

3 ECTS 90 hours study time	25,5 contact hours theory
	13 contact hours exercises/laboratory sessions/visits
	0 contact hours personal work

Learning Outcomes

- To familiarise students with the basic aspects of material science as they apply to nuclear systems
- To learn the basic processes of material degradation and ageing due to the nuclear environment (esp. radiation effects and fatigue).

Content

- Brief review of most important mechanical properties of materials
    - stress-strain relationship
    - ductile and brittle fracture; ductile-brittle transition
    - fatigue failure
    - creep
- Stress analysis: stress intensity, thermal stresses
- Functional requirements of materials in a nuclear environment
    - “nuclear” materials: fuel, fuel cladding, moderator/reflector, coolant
    - structural materials: reactor internals and vessel, piping, valves
- Degradation mechanisms of materials in a nuclear environment
    - radiation effects: general principles, atomic displacements, embrittlement, swelling fatigue: due to thermal stresses and stratification
    - corrosion: p.m. (to be developed in course “Nuclear Materials II”)
- Introduction on treatment of important materials in a nuclear environment (especially nuclear-mechanical interactions and relationships)
    - fuel and cladding
    - moderator/reflector
    - structural materials (incl reactor internals, reactor vessel).

Course Material and Reference Books

The PowerPoint presentations of the lectures, and extensive lecture notes, are available on the BNEN website.

Other useful references:

- Benjamin, M., Nuclear Reactor Materials and Applications, Van Nostrand Reinhold, 1983.
- Glasstone, S. & A. Sesonske, Nuclear Reactor Engineering, 4-th Ed, Vol 1, Chapman & Hall, New York, 1994 (Chapter 7: Reactor Materials, pp 406-462).

PRE-ASSUMED KNOWLEDGE OR PREREQUISITES

The following BNEN courses are a prerequisite

- Nuclear Energy: Introduction
- Introduction to Nuclear Physics and Measurements

Basic chemistry, material behaviour.

GRADING AND EXAMINATION

Oral examination; written preparation.

Nuclear Fuel Cycle

Prof. Pierre Van Iseghem – Université de Liège
Prof. Hubert Druenne – Université de Liège

3 ECTS 90 hours study time	26,5 contact hours theory
	6,75 contact hours exercises/laboratory sessions/visits
	0 contact hours personal work

Learning Outcomes

The objective is to provide students an overall view of the fuel cycle, from cradle to grave:

- The front-end of the fuel cycle: ore extraction, conversion and enrichment, fuel fabrication and use in the power plant, spent fuel reprocessing and recycling of re-enriched reprocessed U and Pu as MOX in PWR.
- The back-end of the fuel cycle: the radioactive waste management, ranging from waste characteristics, waste treatment technologies, disposal technologies, safety assessment of geologic disposal.

Content

First part – The front-end of the fuel cycle (H Druenne)

- Uranium extraction and treatment of ores; worldwide resources ;Conversion of concentrated ores ;
- U enrichment: Basic principles of isotopic separation. Theory of the cascade (symmetrical cascade) and description of the main techniques;
- Fabrication process and description of the various current commercial fuel types;
- Basics of the in-core fuel management;
- Isotopic evolution under irradiation regarding residual heat and source term;
- Reprocessing of UO2 fuel elements: description of the PUREX process ;
- Recycling of U and Pu: technology and industrial limits, equivalence principle and MOX neutronic design;
- Interim storage : description of the main concepts for dry and wet storage.

Second part – The back-end of the fuel cycle (P. Van Iseghem)

- Categories, inventory of radioactive waste
- Conditioning and immobilisation of radioactive waste

- Characterization of radioactive waste (general; scaling factors; destructive analysis; non-destructive analysis)
- Assessment of the safety of geological disposal (methodology; some typical results from the safety assessment)
- Impact of new fuel cycles on radioactive waste disposal
- Geological repositories: key criteria for designing a disposal concept, overview of ongoing international programmes, and discussion of the Belgian supercontainer concept.
- Technical visits to the Belgoprocess facility and to the ESV underground research laboratory in clay on the SCK•CEN site

COURSE MATERIAL AND REFERENCE BOOKS

NOT PROVIDED

PRE-ASSUMED KNOWLEDGE OR PREREQUISITES

The following BNEN courses are a prerequisite

- Nuclear Energy: Introduction
- Introduction to Nuclear Physics and Measurements

Basic chemistry, material sciences, nuclear physics

GRADING AND EXAMINATION

Oral examination; written preparation.

Radioprotection

Prof. Klaus Bacher – Universiteit Gent
Prof. Hubert Thierens - Universiteit Gent

3 ECTS 133,5 hours study time	37 contact hours theory
	15 contact hours excersises/lab sessions/visits
	0 contact hours personal work

Learning Outcomes

The aim of the course is:

- to introduce the student to the physical principles of the interaction of subatomic particles and high-energy radiation with matter
- to learn how to apply the concepts of external/internal radiation dosimetry
- to introduce the student to the biologic effects of ionising radiation
- to learn how to apply dispersion models
- to be able to calculate the effects of shielding materials
- to know the concepts and legislation of radiation protection
- to give an overview of the different methods for detecting and quantifying the presence of such particles and radiation
- to give an introduction to the principles of particle acceleration

Content

Part H. Thierens and K. Bacher

1: Radiological quantities and units

1.1 : Exposure and kerma

1.2 : Absorbed dose

1.3 : Equivalent dose

1.4 : Effective dose

1.5 : Operational dose quantities

2: External dosimetry

2.1 : Ionometry of low energy photon fields

2.2 : High energy photon fields: the Bragg Gray relation

2.3 : Dosimetry of neutron fields

3: Internal dosimetry

3.1 : Concept of committed dose equivalent

3.2 : Concept of specific effective energy

3.3 : Compartmental model analysis

3.4 : Dosimetric model for the respiratory system

3.5 : Dosimetric model for the gastrointestinal tract

3.6 : Dosimetric model for bone

3.7 : Metabolic data of important fission products and actinides

4: Biological effects of ionizing radiation

4.1 : Deterministic and stochastic effects

4.2 : Overview of direct effects including utero

4.3 : Overview of late effects: the UNSCEAR report

4.4 : Biological effect models used in radiation protection

5: Engineering aspects of radiation shielding

5.1 : Build up factors

5.2 : Shielding of photon fields

5.3 : Shielding of combined neutron-photon fields

6: Dispersion of effluents from nuclear facilities

6.1 : Meteorology of dispersion

6.2 : Diffusion of effluents-Pasquill conditions

6.3 : External dose from plume

6.4 : Internal dose from inhalation

7: Legislation and regulations

7.1 : The ICRP 103 publication

7.2 : The conceptual framework of radiological protection

7.3 : The system of protection in occupational and public exposures

7.4 : The system of protection in interventions, accidents and emergencies

8: Measurement techniques in radiation protection

8.1 : Ionometry

8.2 : Film dosimetry

8.3: TLD dosimetry

8.4: OSL dosimetry

COURSE MATERIAL AND REFERENCE BOOKS

The PowerPoint presentations of the lectures, and extensive lecture notes, are available on the BNEN website.

Other useful references:

- Stefaan Tavernier, Experimental techniques in Nuclear and Particle Physics, Springer Verlag, 2010
- Glenn Knoll, Radiation detection and measurement, John Wiley & Sons, 2000

- N.M. Schaeffer, "Reactor Shielding for Nuclear Engineering", Atomic Energy Commission, USA, 1973
- A.E. Profio, "Radiation Shielding and Dosimetry", Wiley, NY, 1979
- J. Wood, "Computational Methods in reactor Shielding", Pergamon Press, Oxford, 1982
- Herman Cember, Thomas Edward Johnson, "Introduction to health physics',
  The McGraw-Hill Companies, 2008
  ICRP, "Publication 103: Recommendations of the ICRP", Elsevier, 2008

PRE-ASSUMED KNOWLEDGE OR PREREQUISITES

The following BNEN course is a prerequisite:

- Introduction to Nuclear Physics and Measurements

It is also assumed that the students have a good background in basic physics as is usually part of the curriculum of the first two years of engineering, physics or mathematics. More in particular they should be familiar with classical theory of electromagnetism and classical mechanics.

An introductory level knowledge to electronics and circuit theory is also assumed.
Students should preferably also have an elementary knowledge of special relativity.

The course contains a short reminder of this subject, but this is probably difficult to comprehend for students who never had an introduction to special relativity. A basic knowledge of quantum mechanics is helpful but not essential.

GRADING AND EXAMINATION

Written examination. Exercise part: "open book", theoretical part "closed book".

Report of lab sessions account for 20% in the total mark.

Nuclear Thermal Hydraulics

Prof. Yann Bartosiewicz – Université catholique de Louvain

5 ECTS 140 hours study time	30 contact hours theory
	24 contact hours exercises/laboratory sessions/visits
	14 contact hours personal work

Learning Outcomes

- To learn how to estimate the volumetric heat generation rate in fission reactor cores under normal operation and shutdown conditions
- To learn how to analyse the thermal performance of nuclear fuel elements
- To learn the basic fluid mechanics of single phase reactor cooling systems
- To learn to calculate pressure drop in reactor systems, including tube bundles, and spacer grids
- To learn to analyse the heat transfer characteristics of single phase reactor cooling systems
- To learn the basic fluid mechanics of two-phase systems, including modelling approaches, flow regime maps, void-quality relations, and pressure drop evaluation
- To learn the fundamentals of boiling heat transfer, and its implications for reactor design
- To calculate and analyze the coolant conditions throughout a reactor loop including the determination of natural convection regime
- To learn the fundamentals of core thermal design, e.g. flow rate/pressure drop relation under different conditions (friction dominated/gravity dominated) for the evaluation of cooling performances

In addition of supervised exercises, a mini-project is organized about modelling and computing pressure drop in a boiling channel (different conditions and assumptions may be treated over the years).

Content

- Thermal design principles/reactor heat generation
- Reminders about single phase transport equations (prerequisite)
- Two-phase flow models, transport equations
- Thermodynamic (vessels/pressurizer) and power conversion cycle (steam)
- Heat transfer analysis in a fuel element
- Reminders about single phase fluid mechanics and heat transfer (prerequisite)
- Two-phase fluid mechanics and pressure drops
- Two-phase heat transfer (pool boiling, flow boiling)
- Single heated channel (thermal and flow problems)
- Flow loops (steady state natural convection)

COURSE MATERIAL AND REFERENCE BOOKS

The PowerPoint presentations of the lectures, and additional lecture notes, are available on the BNEN website.

Other useful references:

- Todreas, N.E. and Kazimi, M.S. Nuclear System I: Thermal Hydraulic Fundamentals, Taylor & Francis, Boca Raton, 2012.

PRE-ASSUMED KNOWLEDGE OR PREREQUISITES

A relevant course about introduction to nuclear energy

Fundamental of fluid mechanics, heat transfer, thermodynamic

GRADING AND EXAMINATION

The final mark is composed of (i) a written exam(80%, closed book)including an exercise and a theoretical part, and (ii) the mini-project(20%).

Nuclear Reactor Theory

Prof. William D'Haeseleer – Katholieke Universiteit Leuven
Prof. Jean-Marie Noterdaeme – Universiteit Gent
Prof. Peter Baeten – Vrije Universiteit Brussel

6 ECTS 198 hours study time	44 contact hours theory
	24 contact hours exercises/laboratory sessions/visits
	0 contact hours personal work

Learning Outcomes

- To understand the physical processes involved in a nuclear reactor
- To understand and be able to write down and solve the basic equations
- To be able to simulate a reactor/source configuration (geometry, composition) as appropriate depending on:
  - -number of dimensions;
  - -steady state or transient;
  - -number of groups;
  - -delayed neutron precursors;
  - -space dependent properties.
- To learn how to measure neutron distributions and parameters relevant for nuclear reactors, in particular reactivity and reactivity coefficients

Content

- Physics of nuclear reactors
- Transport and diffusion
- Spatial dependence
- Slowing down theory
- Resonance integrals
- Cell calculations
- Neutron thermalisation
- Multigroup equations
- Criticality dependence on geometry and composition
- Reactivity and control
- Reactor dynamics
- Reactor codes
- Neutron sources and detectors
- Basic measurements: source strength, neutron flux (activation analysis, neutron counting), neutron spectrum reaction rates
- Activity, dose and cross-section measurement
- Measurement of neutron transport parameters: stationary methods, pulsed neutron experiments

- Measurement of reactivity (and reactivity coefficients): survey, static methods, dynamic measurements, inverse kinetics, neutron noise fluctuation methods

COURSE MATERIAL AND REFERENCE BOOKS

The PowerPoint presentations of the lectures and lecture notes are available on the BNEN website.

Other useful references:

- J.J. Duderstadt and L.J. Hamilton, "Nuclear Reactor Analysis", 1976 (Wiley & Sons)
- Lamarsh, J.R., "Introduction to Nuclear Reactor Theory", Addison-Wesley, Reading, Mass., 1966
- Profio, A.E., Experimental Reactor Physics, J. Wiley, 1976
- P. Reuss, "Neutron physics", 2008 (EDP Sciences)

PRE-ASSUMED KNOWLEDGE OR PREREQUISITES

The following BNEN courses are a prerequisite

- Nuclear Energy: Introduction
- Introduction to Nuclear Physics and Measurements

Mathematics (differential equations, taylor expansions, fourier expansions, bessel functions)

GRADING AND EXAMINATION

Written examination, open book.

Safety of nuclear power plants

Prof. Hubert Druenne – Universiteit Gent
Prof. Pierre- Etienne Labeau – Université Libre de Bruxelles
Seminars: Prof. André Poucet – KU Leuven ; Prof. Greet Maenhout – Universiteit Gent

5 ECTS 141 hours study time	42 contact hours theory
	6 contact hours exercises/laboratory sessions/visits 4 hours seminar
	0 contact hours personal work

Learning Outcomes

To introduce the students to methods and practices supporting the defense-in-depth approach for nuclear power plants.

More specifically:

- To present elements of nuclear safety philosophy.
- To understand how to insure the link between nuclear safety and reactor operation.
- To master all the contributors to the core reactivity balance and power distribution in normal operation.
- To understand specific measurement and control issues in nuclear reactors.
- To introduce the basic notions and techniques of system reliability engineering.
- To understand the concepts of safety analyses (both deterministic and probabilistic), and the fundamentals of probabilistic safety analysis (PSA).
- To present some PSA-based applications.

Contents

Operation & Control (28h)

- Cycle specific safety evaluation methodology.
- Basic principles of the in-core fuel management based on the linear reactivity model.
- Reactivity coefficients (moderator, Doppler), neutron poisons (xenon, samarium, …), their variation with burnup and core state parameters and their impact on core power distribution.
- Reactivity control means (boron, control rods, burnable poisons) and their sensitivity to the core burnup and in-core fuel management parameters.
- Operating modes, operating limits and protection diagram.
- Fuel rod design and thermal-mechanical behavior in normal operation and accidental conditions.
- Thermal design procedures and elaboration of the core thermal limits and core protections.
- Core control, surveillance and protection systems

Optional visits and laboratory session:

- Visit of a Nuclear Power Plant.
- Two day session of compact and full scope Nuclear Power Plant simulator.

Seminars: Overview of design basis accidents and severe accidents; Discussion of selected past nuclear (severe) accidents (TMI, Chernobyl, Fukushima-Daiichi…)

Reliability & Safety (14h theory + 6h exercises)

- Introduction to nuclear safety and defence in depth
- concept of risk, individual and societal risk criteria, release limits, core damage frequency limit, safety goals at function or system level
- deterministic vs. probabilistic safety analyses;
- probabilistic safety assessment (PSA) methodology and PSA levels
- Component reliability
- Fault tree and event tree analysis
- Markov analysis
- Common cause failure analysis
- Elements of human reliability analysis
- Elements of the level 2 and level 3 PSA methodology
- Limits of the classical PSA methodology
- PSA-based applications

Operation & Control

- Collection Génie Atomique "La chaudière des réacteurs à eau sous pression" Ed. EDP Sciences, 2004
- Collection Génie Atomique « Exploitation des cœurs REP », Ed. EDP Sciences, 2008
- USNRC Technical Training Center, « Pressurized Water Reactor Systems"

Reliability & Safety

- McCormick, N., Reliability and Risk Analysis – Methods and Nuclear Power Applications, Academic Press, New York, 1981.
- Henley, E.J. and Kumamoto, H., Reliability Engineering and Risk Analysis, Prentice Hall, Englewood Cliffs, 1981.
- Modarres, M., What Every Engineer Should Know about Reliability and Risk Analysis, Dekker Inc., New York, 1993.
- Kumamoto, H., and Henley, E.J., Probabilistic Risk Assessment and Management for Engineers and Scientists, 2nd Edition, John Wiley & Sons, New York, 2001.
- Bedford, T. and Cooke, R., Probabilistic Risk Analysis, Foundations and Methods, Cambridge University Press, New York, 2001.

PRE-ASSUMED KNOWLEDGE OR PREREQUISITES

Courses in the following field

- Nuclear reactor theory
- Nuclear thermal hydraulics

GRADING AND EXAMINATION

Operation & Control

First and second session: Individual oral exam, closed book, written preparation.

Reliability & Safety

First and second session: An oral examination (closed book) with one question on the concepts and one exercise.