South Africa is leading the nuclear Renaissance in Africa, and is recognized internationally for the development of a High Temperature Gas-Cooled Reactor led by the PBMR Company. Government has recently made public statements indicating continuing support for nuclear as a low carbon power generation option, as well as the PBMR as a contender for co-generation and process heat supply.

South Africa will require a new generation of nuclear experts when the electricity utility, ESKOM, launches its nuclear programme. Skilled staff is required for construction, management, operation and maintenance of the envisioned fleet of Pressurized Water Reactors (PWR) nuclear power plants as well as the redesigned PBMR demonstration power plant.

North-West University was the first university in South Africa to be awarded a chair in Nuclear Engineering by the Department of Science and Technology and the PBMR (Pty) Ltd and is thus well positioned to provide quality, industry-specific training and education for the emerging nuclear industry in South Africa.

The Post-graduate School of Nuclear Science and Engineering offer the following qualifications:

- M.Eng
- M.Sc
- PhD
- Diploma in Nuclear Science & Technology
- Short Courses, ECSA accredited

In 2009 three new modules were introduced to the Mechanical Engineering Undergraduate programme.

These provide excellent graduate education for engineers and scientists seeking a career in the broader nuclear industry or the power generation industry.

Be part of the solution for the growing energy demand!
<table>
<thead>
<tr>
<th>INDEX</th>
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</thead>
<tbody>
<tr>
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<td>10</td>
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<td>11</td>
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<tr>
<td>12</td>
</tr>
</tbody>
</table>
North-West University’s involvement in the nuclear field can be summarized as follows:

- The Centre for Applied Radiation Science and Technology (CARST) at the Mafikeng campus started with the MARST (Masters in Applied Radiation Science and Technology) programme in 1996. CARST awarded more than 60 masters degrees since 2000 and most graduates were successful in finding positions in the nuclear industry.

- The engineering faculty has been involved with the PBMR project since 1997. It runs a substantial research programme in support of the PBMR project, which involves more than 50 post graduate students. The programme is co-funded by PBMR and THRIP.

- During 2002 the Faculty developed, with input from PBMR staff, a physical model of the power conversion unit (PCU) of the PBMR that demonstrated the feasibility of the PBMR PCU concept. The successful start-up of the prototype during September 2002 was a key milestone in the development of the PBMR and represented a world-first for this particular plant configuration.

- The Faculty of Engineering has signed collaboration agreements with well known overseas nuclear engineering research institutions such as the Institut für Kernenergetik und Energiesysteme (IKE) at the University of Stuttgart and Hacettepe University in Turkey. It also has associations with MIT, Cranfield University, the Technical University of Delft and Manchester University.

- North-West University is a member of the World Nuclear University that was inaugurated in 2003 and faculty members are actively involved in the field by inter alia serving on editorial boards of international nuclear engineering journals and advisory committees of the IAEA. North-West University is also a member of the World Nuclear Association.

- In 2005 the Department of Science and Technology and PBMR awarded the first Chair in Nuclear Engineering to the North-West University.

- The Postgraduate School of Nuclear Science and Engineering houses three different PBMR sponsored test facilities at its Potchefstroom Campus. These are the: Pebble Bed Micro Model (PBMM), High Pressure Test Unit (HPTU), and the High Temperature Test Unit (HTTU).

- NWU is the first university outside of Europe to be admitted as an associate member of the European Nuclear Education Network (ENEN, see http://www.enen-assoc.org). Membership of ENEN is subject to stringent quality assurance requirements.
Both the M.Eng and the M.Sc programmes are available in two options namely; Option B and Option C. Option B consists of 50 percent taught modules and 50 percent thesis work, while Option C consists of 75 percent taught modules and 25 percent project work.

Option C will be available by default to applicants who meet the minimum entry requirements or are allowed to the program by RPL.

Participants will only be allowed into Option B on application to and recommendation by the selection panel of the School. This selection will be based on the candidate’s proven track record, research abilities and the availability of a suitable project and research supervisor.

The credits and composition for fundamental, core and elective components of the two options are summarized in Table 1.

Table 1: The Structure of the master programmes in nuclear engineering.

<table>
<thead>
<tr>
<th>Component</th>
<th>Option B</th>
<th>Option C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Credits</td>
<td>Composition</td>
</tr>
<tr>
<td>Dissertation (compulsory)</td>
<td>92</td>
<td>Dissertation</td>
</tr>
<tr>
<td>Fundamental and core modules (compulsory)</td>
<td>56</td>
<td>1x8 credit module + 3x16 credit modules</td>
</tr>
<tr>
<td>Elective modules</td>
<td>32</td>
<td>2x16 credit modules</td>
</tr>
<tr>
<td><strong>TOTAL CREDITS</strong></td>
<td><strong>180</strong></td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. One credit represents 10 notional study hours.

The focus of Option B theses should be on a nuclear point of view (i.e. context and synthesis).
Table 2: The following modules are offered as part of the two programmes:

<table>
<thead>
<tr>
<th>CODE</th>
<th>MODULE</th>
<th>CREDITS</th>
<th>PRE-REQUISITE</th>
<th>M.Eng/MSc Option B</th>
<th>M.Eng/MSc Option C</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVMI874</td>
<td>Research Methodology</td>
<td>8</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NUCI511</td>
<td>Nuclear Engineering I</td>
<td>16</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NUCI883</td>
<td>Nuclear Engineering II</td>
<td>16</td>
<td>NUCI511, NUCI621, NUCI671</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NUCI887</td>
<td>Reactor Analysis</td>
<td>16</td>
<td>NUCI883</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NUCI888</td>
<td>Reactor Safety</td>
<td>16</td>
<td>NUCI883, NUCI887</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NUCI874</td>
<td>Advanced Reactor Analysis I</td>
<td>16</td>
<td>NUCI887</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NUCI876</td>
<td>High Temperature Gas-Cooled Reactor Thermal-Fluid Analysis</td>
<td>16</td>
<td>NUCI883, MGI885</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NUCI 877</td>
<td>HTR Fuels and Materials</td>
<td>16</td>
<td>NUCI883, NUCI887</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NUCI878</td>
<td>High Temperature Reactor Technology</td>
<td>16</td>
<td>NUCI883, NUCI887</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NUCI879</td>
<td>Nuclear Project Management</td>
<td>16</td>
<td>NUCI511</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NUCI886</td>
<td>Pebble Bed Reactor Design</td>
<td>16</td>
<td>NUCI883, NUCI874</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>MGI885</td>
<td>Thermal-Fluid Systems Modelling I</td>
<td>16</td>
<td>NUCI621</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>MGI886</td>
<td>Thermal-Fluid Systems Modelling II</td>
<td>16</td>
<td>MGI885</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>MEGN871</td>
<td>Pressurized Water Reactor Technology</td>
<td>16</td>
<td>NUCI883, NUCI887</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>MEGI874</td>
<td>Computational Fluid Mechanics I</td>
<td>16</td>
<td>NUCI621</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NUCI882</td>
<td>LWR Thermal-Hydraulics</td>
<td>16</td>
<td>NUCI883, MGI885</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NUCI872</td>
<td>Dissertation</td>
<td>92</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NUCI873</td>
<td>Mini-Dissertation</td>
<td>44</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

As of the academic year 2010, the available modules in the program are offered in four structured tracks as shown in the following table.

The first four modules are common to all the tracks and are compulsory.

The optional modules may then only be taken in a group context within the selected track.

This ruling is aimed at enhancing the sustainability of the program and ensuring a holistic learning experience for the student.

---

2 NUCI 874 (Advanced Reactor Analysis I) will replace NUCI 511 (Nuclear Engineering I) as the compulsory module for students who enter the masters programme from the Postgraduate Diploma (Nuclear Engineering)
### AVAILABLE STUDY TRACKS

<table>
<thead>
<tr>
<th>Track</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NUCI 511</td>
<td>Nuclear Engineering I</td>
</tr>
<tr>
<td>2</td>
<td>NUCI 883</td>
<td>Nuclear Engineering II</td>
</tr>
<tr>
<td>3</td>
<td>NUCI 887</td>
<td>Reactor Analysis</td>
</tr>
<tr>
<td>4</td>
<td>NUCI 888</td>
<td>Reactor Safety</td>
</tr>
<tr>
<td>5</td>
<td>NUCI 871</td>
<td>PWR Technology</td>
</tr>
<tr>
<td>6</td>
<td>MGII 885</td>
<td>Thermal Fluid Systems Modelling I</td>
</tr>
<tr>
<td>7</td>
<td>MGII 886</td>
<td>Thermal Fluid Systems Modelling II</td>
</tr>
<tr>
<td>8</td>
<td>NUCI 882</td>
<td>LWR Thermal-Hydraulics</td>
</tr>
</tbody>
</table>

### AREAS OF RESEARCH

The School runs a comprehensive research programme in support of the emerging nuclear industry in South Africa. The different areas of research include the following:

- PWR Systems Analysis
- HTR System Analysis
- HTR Reactor Design
- Nuclear Engineering Management

Students need to identify a project and study leader by the end of the first year of study.
4 ENTRY REQUIREMENTS

The entry requirements for the two programmes are as follows:

- for the M.Eng. degree: a four year engineering degree; and
- for the M.Sc. degree:
  - a B.Sc degree with Mathematics, Applied Mathematics or Physics at least to the third year level or
  - a B.Tech degree in Engineering (Mechanical, Electrical or Chemical) plus a B.Sc Honours degree in Physics or Mathematics or
  - Postgraduate Diploma in Nuclear Engineering (to be offered by NWU pending final approval).

Students not in possession of either a B.Eng (Mechanical) or a B.Eng (Chemical) degree must register for Thermal-Fluid Sciences (NUCI 621) which will be a bridging module.

Students coming through the B.Sc Honours route must also register for Mathematics for Nuclear Engineers (NUCI 671) which will be a bridging module.

The credits for the two bridging modules do not count towards the 180 credits for the master’s degree. It is not necessary to complete the bridging modules before registering for the regular modules but compulsory that the exams of the bridging modules are passed before continuing with the degree. Students can register for the bridging modules and the available modules in the same year.

5 METHOD OF PRESENTATION

A module is presented by a blended distance-contact model to provide access to the course for students who are already in a career, and working away from the University Campus.

The distance learning component of the course is facilitated by an e-learning platform, e-Fundi which has an interactive site for each module, and enables students to participate in well structured self-study learning activities prior to attending the contact lecture sessions.

Bridging modules are usually covered in four weeks, one of which serves as a contact week. The other modules are usually delivered over eight weeks of which one serves as a contact week. The weeks following the contact sessions are earmarked for self-study, assignments and assessment.

Exam will take place on the last Friday of the eight week period.
Applications should be submitted before 30 November of each year.

A pro forma application form must be obtained and submitted together with a academic record or proof of qualification to Bessie Danilatos e-mail: 10000836@nwu.ac.za. The pro forma application form will be presented before the school’s screening committee.

Once accepted by the committee, obtain the formal NWU application form from Melleney Campbell-Jacobs e-mail: 22214518@nwu.ac.za or

http://www.puk.ac.za/fakulteite/ing/nuclear/index_e.html and follow instructions on the application form.

Application process

- Complete the pro forma application form (include academic record or proof of qualifications) and submit to Postgraduate School for Nuclear Science and Engineering
- If accepted by screening committee, complete the application form (include ALL requested documents)
- Post the completed documentation by registered mail to:
  Attention: Admissions – Melleney Campbell-Jacobs
  North-West University Potchefstroom Campus
  Private Bag X6001
  2520 POTCHEFSTROOM, RSA
- Include the application fee of R150-00 or the deposit slip (proof of payment with your Surname as reference)
- After your application has been evaluated and approved, you will receive a letter of confirmation that your application has been successful.

Registration process

- Submit the completed pro-forma registration form to Bessie Danilatos (by fax 018-299 4369 or email 10000836@nwu.ac.za).
- A registration document will be posted to your postal address. On this document you should also indicate the modules you want to register for (the same modules as indicated on the pro-forma form). The original registration document must be submitted to the university. Registration must take place before attending any classes.
- Registration involves: The completed registration document (original) together with the payment of your registration fee and 35% of the programme fee (Fees for 2010 will be confirmed and the mentioned fees are only a figure).
- **If you are a bursary holder, the responsible company** should submit a letter, confirming that they will be responsible for all your fees. If the university does not receive either the amount for registration or the letter, you cannot be registered and thus, not take part in lectures or write the exams.
7  TUITION FEES

The tuition fees for 2009 for both the masters’ programmes are:

- The tuition fee of R19 379, which includes the study guides but excludes text books, travel and accommodation. The fees tuition fee for 2010 will be available from January 2010.
- Application fee of R150
- Registration fee of R910

The schedule for the payment of tuition fees is as follows:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>PERCENTAGE OF TUITION FEES PAYABLE</th>
<th>PAYABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>35%</td>
<td>Subject to increase</td>
</tr>
<tr>
<td>3</td>
<td>30%</td>
<td>Subject to increase</td>
</tr>
</tbody>
</table>

Students who finish the programme in two years will have to pay only 70% of the total tuition fees and those who finish in three years will have to pay 100% of tuition fees.

8  POSTGRADUATE BURSARIES/ SCHOLARSHIP

Different bursary options are available for postgraduate students. When a student is approved to enter into the Masters programme in Nuclear Engineering, he/ she may apply for a PUK-bursary. To be considered for this bursary, the student should have obtained a final grade of 60% for his/ her B.Eng or B.Sc Hons. The contact person is:

Susan van der Westhuisen  +27 18 299-2188

The following institutions also offer bursaries for students entering into postgraduate studies in Nuclear Engineering (The contact persons name is also included for convenience):

PBMR:  Ilze Taylor  +27 12 641 1000
NECSA: Selebale Monageng +27 12 305 5404
ESKOM: Mike Brown  +27 51 404 2706
BRIDGING MODULES

**NUCI621 THERMAL-FLUID SCIENCES**

Thermodynamics: properties of pure substances, work and heat, First Law of Thermodynamics, Second Law of Thermodynamics, power cycles; Fluid mechanics: dimensional analysis, conservation laws for control volumes, incompressible viscous flow through pipes, one-dimensional compressible flow; Turbo machinery: basic laws, compressors, turbines; Heat transfer: conduction, convection and radiation heat transfer, heat exchangers.

**NUCI671 MATHEMATICS FOR NUCLEAR ENGINEERS**

Differential Equations; Systems of Differential Equations; Vector Calculus; Special Functions; Fourier Analysis; Partial Differential Equations; Numerical Methods.
COMPULSARY MODULES

NUCI511 NUCLEAR ENGINEERING I
Atomic and nuclear physics, interaction of radiation with matter, nuclear reactors and nuclear power, neutron diffusion and moderation, nuclear reactor theory, the time dependent reactor, heat removal from nuclear reactors, radiation protection, radiation shielding, reactor licensing, safety and the environment.

NUCI883 NUCLEAR ENGINEERING II
Design and operating principles of various nuclear reactors and fuel, licensing and safety considerations of various reactor types, neutronics and coupled thermal-hydraulic, fuel design basis of various nuclear technologies, nuclear fuel cycles, safety systems of various nuclear reactors, fuel management and cost.

NUCI887 REACTOR ANALYSIS
Neutron nuclear reactions, nuclear chain fission reactors, neutron transport theory, neutron diffusion theory, neutron slowing down, resonance absorption, neutron energy distribution, fuel burn up, nuclear reactor dynamics.

NUCI888 REACTOR SAFETY
Safety concepts, defence-in-depth principle, radiation protection, source term and fission product transport, shielding design, attenuation calculations, reactor accidents and inherently safe reactors, deterministic and probabilistic risk analysis, environmental impacts, reactor siting, reactor licensing.

NVMI874 RESEARCH METHODOLOGY

Experimental Procedure and data generation: Approach to experimentation, reliability of measurements, repeatability, accuracy, experimental design and documentation. Data Processing: Knowledge and use of advanced data processing methods; statistical analysis, regression analysis, presentation.

Report Writing: The writing of theses, dissertations and papers; style of presentation, critical approach, conclusions.

Software for Research Management: Use of software programmes such as Research Toolbox.
ELECTIVE MODULES

MGII885 THERMAL-FLUID SYSTEMS MODELLING I
Introduction to system simulation; Integrated system simulation applied to various power plant configurations; Fundamental principles of thermal-fluid simulation; Steady-state incompressible and compressible pipe flow simulation; Introduction to steady-state heat exchanger simulation; Transient simulation.

MGII886 THERMAL-FLUID SYSTEMS MODELLING II
Integrate comprehensive and advanced knowledge of thermodynamics, fluid mechanics and heat transfer with specialized techniques required to simulate complex thermal-fluid systems for both steady state and transient conditions.
Apply higher level engineering synthesis skills and specialised software tools to create mathematical models with the appropriate degree of complexity that can be used in the simulation and design of advanced thermal-fluid components and complex systems.

MEGI874 COMPUTATIONAL FLUID MECHANICS I
Modern CFD with its extensions to multi-phase flows, structure interaction and systems approaches is wide and general and covers most of the issues and techniques that apply to the field numerical transport theory. It is applied to the Navier-Stokes equations within the Multi-Phase flow Finite Volume framework on arbitrary unstructured grids as implemented into commercial codes such as Fluent and Star-CD. One of the objectives of the course is to give CFD analysts an understanding of the underlying structure of the software and methods that applies to commercial CFD software usually available as “black box” solutions. The course also equips researchers interested in the field of Transport Phenomena Simulation Software development with a suitable background for code and methods development.

NUCI871 PRESSURIZED WATER REACTOR TECHNOLOGY
Light water reactor core physics; Design of fuel elements and core: design bases for Koeberg NPP core design; Components of reactor: design bases for reactor pressure vessel reactor internals, control rods; Components of Primary system: design bases for MCP, PRZR (PORV and safety valves) SG, MSIV, GCT to ATM etc.; Design bases transient and accident analysis: SAR requirements, ECCS acceptance criteria, design conditions of the PWR plants; Regulatory framework (NNR, NRC, IAEA): Codes, standards, specifications.

NUCI874 ADVANCED REACTOR ANALYSIS I
Neutron transport theory (Sn, Pn derivation), neutron diffusion theory (FD, codes), neutron energy distribution, neutron thermalization, reactivity changes (burn up, point kinetics), Introduction to Monte Carlo methods (basic equations, approaches, cross sections, statistics).
NUCI876 HIGH TEMPERATURE GAS-COOLED REACTOR
THERMAL-FLUID ANALYSIS
Coolant choice and properties, solid materials thermal properties; Pebble bed core properties: porosity distribution, flow distribution, pressure drop; Heat production and distribution; Core heat transfer phenomena and modelling: conduction, radiation, convection, dispersion; Numerical modelling of integrated heat transfer and fluid flow inside the reactor.

NUCI877 HIGH TEMPERATURE REACTOR FUELS AND MATERIALS
Preparation of HTR fuel, fuel characteristics, radiation effects on fuel, burn up and fuel performance, structural and radiation properties of graphite, high temperature materials, material selection.

NUCI878 HIGH TEMPERATURE REACTOR TECHNOLOGY
Principal aspects of HTR and applications, core physics, design and lay-out of fuel elements and core, thermo-hydraulic of core, reactor components, primary system components, safety and licensing, accidents analysis, operational aspects, coolant and materials (tribology of helium), intermediate and final storage, cost aspects, development of HTR.

NUCI879 NUCLEAR PROJECT MANAGEMENT
The purpose of the module is to use problem-based learning to provide a thorough understanding of all aspects of project management theory and practice. The module will focus on the following key themes: planning, cost, and value management; project control; human issues in project management; strategic issues in project management; commercial and procurement law.

NUCI882 LWR THERMAL-HYDRAULICS
LWR Thermal Hydraulics examines detailed thermal hydraulic analysis with an emphasis on those TH phenomena important to Light Water Reactor (LWR) design and operation. Specifically, analysis of the transport equations for single and two-phase flow is presented with an added emphasis on two-phase flow dynamics and heat transfer. Analysis methods for LWR power stations will then be introduced via the formulation of reactor thermal hydraulic design problems. Particularly, steady state and transient analysis of single, heated channels will be covered.

NUCI886 PEBBLE BED REACTOR DESIGN
Physical processes in a reactor, modelling / computational representation of individual events in reactor operation, the interaction of individual events, simulation of fuel cycles, reactor life and accident simulation, design project.
10 QUALITY CONTROL

The North-West University employs a comprehensive quality assurance system for all its academic programmes. A component of this system focuses specifically on the distance-contact postgraduate programmes. The University ensures that the nuclear engineering programmes comply with the highest standards as required by the Higher Education Quality Committee (HEQC) and professional bodies such as the Engineering Council of South Africa (ECSA).

11 ENQUIRIES:

Me. Bessie Danilatos  
Post-graduate School of Nuclear Science and Engineering  
Faculty of Engineering  
North-West University (Potchefstroom Campus)  
Tel: (018) 299-1355  
Fax: (018) 299-4369  
E-mail: 10000836@nwu.ac.za

12 WEBSITE

http://www.puk.ac.za/fakulteite/ing/nuclear/index_e.html

13 ACADEMIC RULES

Contact the Postgraduate School of Nuclear Science and Engineering.