Scholarly Paper. M.Eng. in Nuclear Engineering

One of the requirements for an M.Eng degree in Nuclear Engineering is to write a scholarly paper, based on a technical topic. This paper should be done under the supervision of a faculty advisor and needs to be approved by the advisor, a reader and the program chair. The student should register for three credits of NucE 597C [M.Eng report writing course] and choose an advisor based on the paper topic area.

The paper should be indicative of the scholarly ability of the student, and demonstrate the ability to integrate, apply or synthesize existing knowledge to provide an incremental addition on the state of the art and report the work in a scholarly fashion. It should also have an element of assessment and evaluation.

The scholarly paper should be about 30-50 pages long (double spaced) and can be of many different types, as long as it provides added value in the form of new applications, evaluations or synthesis of knowledge, even if incrementally. Some examples of possible paper types are below.

- Use an existing computer code or analytical model to obtain results in previously unexplored applications, perform a sensitivity analysis of a parameter, or an equivalent task. It could also consist of modifying an existing code, for example, by adding subroutines to perform new functions. The paper should also analyze the results and provide understanding.
- Experimental report. In case the student has access to experimental apparatus, they can conduct simple experiments, report existing data or re-analyze existing experimental data to develop further understanding. An evaluation of the significance of the results should also be provided.
- Perform a critical review of literature on a phenomenon. This means reading the literature, (normally on a well-defined narrow technical subject), analyze, evaluate and synthesize existing technical papers (typically from recognized refereed journals), to provide a good review and evaluation of the state of the art.

The paper should be well written, formatted and carefully prepared. We require that students follow the format template used for M.Sc. theses found at [http://css.its.psu.edu/theses/](http://css.its.psu.edu/theses/), which although designed for MS theses provides a good unified format for the M.Eng. papers.

The following pages list the faculty advisors available and some suggested topics. The student can either propose to the faculty to do their M.Eng. paper on the suggested topic or to suggest and come to an agreement with the faculty member on another topic of common interest, based on the listed areas of research interest. The student is also responsible for securing a second reader.
Possible Advisors are the members of the NucE graduate Faculty listed below

Some of the faculty have suggested specific topics listed below their name indicated by their initials and a number. Please confirm with the faculty member that you have been assigned a topic prior to starting the work.

**Arthur T. Motta**, Chair and Professor of Nuclear Engineering  (814-865-0036) [atm2@psu.edu] Ph.D., University of California- Berkeley, 1988. Irradiation effects in metals and microstructural evolution under irradiation both from an experimental and a theoretical point of view; behavior of materials, especially nuclear fuel cladding, in the nuclear reactor environment including corrosion, hydriding and irradiation effects.

**Maria Avramova**, Assistant Professor of Nuclear Engineering (814-865-0043) [mna109@psu.edu] Ph.D., Pennsylvania State University, 2007. Reactor thermal-hydraulics; core design; transient and safety analysis; multi-physics multi-scale simulations and uncertainty and sensitivity analysis.

**Jack S. Brenizer, Jr.**, J. "Lee" Everett Professor of Mechanical and Nuclear Engineering (814-863-6384) [brenizer@engr.psu.edu] Ph.D., Pennsylvania State University, 1981. Radiation detection, neutron radiography, neutron activation analysis, nuclear materials monitoring devices.

**Gary L. Catchen**, Professor of Nuclear Engineering (814-865-2011) [g9c@psu.edu] Ph.D. Columbia University, 1979. Hyperfine interactions; radiation detection and measurement; radiation dosimetry; developing teaching techniques for nuclear science.

**GC1: Review of safety features and subsequent technical modifications made to first-generation GE BWRs and their connection to safety considerations.** These plants were designed in the late 1960s to be cost competitive (in the US) with coal-fired plants. As such designers may have made compromises either unwittingly as the industry was "young" or to reduce costs. As the industry matured, various parties executed modifications. But not all plants of this generation were modified in the same ways. The aftermath of the tsunami at the Fukushima Daiichi site provides much information about the vulnerabilities of these plants as well as the strengths of the design. Ironically these plants survived the earthquake, even though the strength of the quake was well above the design basis. But the tsunami caused the meltdowns, because the Diesel generators were located in poor locations. This error did not really arise because the plants were poorly designed. We are not sure why the Diesel generators were located below the reactors.

**Fan-Bill Cheung**, Professor of Mechanical and Nuclear Engineering (814-863-4261) [fxc4@psu.edu] Ph.D., University of Notre Dame, 1974. Solidification and Melting; Turbulent Natural Convection; Two-Phase Flow and Heat Transfer; Nuclear Reactor
Thermal Hydraulics and Safety; Thermal Processing of Materials; Thermal Behavior of High-Temperature Ablatives; Dense Spray and Atomization.

**FC1. Evaluation of Thermal Margins for In-Vessel Retention (IVR) in GW-PWRs**

One severe accident management strategy for high-power (1000 megawatt electric) reactors involves in-vessel retention (IVR) by flooding the reactor cavity with water following a severe accident. To demonstrate the viability of IVR, it is necessary to assess the thermal margins which represent the differences between the local critical heat fluxes for downward-facing boiling of water on the reactor vessel outer surface and the local wall heat fluxes from the corium. In this paper, a method will be developed to evaluate the thermal margins utilizing available experimental data.

**FC2. Nucleate Boiling Correlations for Long-Term Cooling of Core Melt**

During the unlikely event of a severe accident, the reactor pressure vessel (RPV) in a nuclear power plant must be adequately cooled to maintain its integrity. This can be achieved by flooding of the reactor cavity with water, whereby the RPV lower head is cooled by nucleate boiling on the vessel outer surface. In this paper, suitable nuclear boiling correlations will be developed from available data to predict the process of long-term in-vessel cooling of core melt.

**FC3. Minimum Film Boiling Temperature for Determination of the Grid-Rewet Conditions**

Experimental results obtained recently from the RBHT Test Facility at Penn State confirm a first-order effect of spacer grids on rod bundle heat transfer during reflood transients. It is now widely recognized that spacer grids promote cooling of fuel rods and thus lowering the peak cladding temperatures (PCTs) in the reflood stage of a loss-of-coolant accidents (LOCA). Heat transfer is low in the reflood stage of a LOCA and the PCTs are reached during this time. In this paper, the reflood data recently obtained at the RBHT Test Facility will be examined to correlate the minimum film boiling temperature for determining the grid-rewet conditions.

**Max Fratoni**, Assistant professor of Nuclear Engineering, (Phone: 814-863-4391 [muf24@psu.edu], Reactor physics, nuclear system design, and fuel cycle analysis.

**MF1: Evaluation of thorium fuel cycle options**

Student will explore literature on thorium-based fuel cycles and select the most promising options. Using various metrics, in particular related to proliferation resistance and environmental impact, the student will rank those options and will compare to uranium-based fuel cycles.

**MF2 Incineration of weapons-grade materials**

Student will evaluate advantages and disadvantages of different options for incineration of weapons-grade materials. Student will derive figure of merits using a depletion code
to model the incineration process for three reactor categories: light water reactor, fast reactor, and sub-critical source-driven reactor.

**Kostadin Ivanov**, Distinguished Professor of Nuclear Engineering (814-865-0040) [kni1@psu.edu] Ph.D., Bulgarian Academy of Sciences. Three-dimensional reactor core analysis; computational methods in reactor statics and dynamics; thermal-hydraulic reactor system transient modeling of power plants; coupled 3-D kinetics/thermal-hydraulic simulations and benchmarking; core design and management. Professional Engineer.

**Igor Jovanovic**, Associate Professor of Nuclear Engineering (814-867-4329) [ijovanovic@psu.edu] Ph.D., University of California – Berkeley, 2001. Nuclear detection and nonproliferation; inertial confinement fusion; ultrafast and intense laser science and technology; remote sensing.

**IJ1. Bremsstrahlung spectral filter modeling:** Many active detection techniques for nuclear materials require high-energy photon sources with relatively narrow energy spectra. The student will employ MCNP to design a spectral filter for a broadband bremsstrahlung photon source to efficiently remove the low-energy region of the spectrum.

**IJ2. Accelerator production of Mo-99:** The isotope Mo-99 is essential for medical applications, is usually produced in nuclear reactors, and has been in short supply in the recent period. The goal of this work is to perform a detailed review of the accelerator-driven methods for Mo-99 production.

**Seungjin Kim**, Associate Professor of Mechanical and Nuclear Engineering (814-867-1783) [sxk86@psu.edu] Ph.D., Purdue University, 1999. Thermal-hydraulics; Reactor Safety; modeling of two-phase flow phenomena; interfacial area transport models; two-phase flow experiment and instrumentation; reactor system analysis code development and Very High Temperature Reactor.

Research topics in the area of reactor thermal-hydraulics: the paper could also include designing and performing scaled experiments as well as pursuing theoretical and computational treatment of multi-phase flows depending on students’ availability and background. Examples may include: modeling of two-phase flow and fluid-particle interactions, nuclear reactor safety analysis; assessment on the current state-of-the-art reactor design; thermal-hydraulic system code validation & verification etc.

**Kenan Unlu**, Director of Radiation Science and Engineering Center and Professor of Nuclear Engineering (814-865-6351) [kxu2@psu.edu] Ph.D., University of Michigan, 1989. Development and Applications of Nuclear Analytical Techniques; Neutron Depth Profiling; Cold Neutron Prompt Gamma Activation Analysis; Neutron Radiography,
Neutron Activation Analysis; Radiation Detection; Radiochemistry; Nuclear Forensics and Nuclear Security Education.

**KU1. Thorium Fuel Cycle: Potential Technical Issues, Challenges and Benefits** (review of the rationale for thorium based fuels cycles, current developments, front end issues and challenges, potential use of thorium in Molten Salt Breeder Reactors)


**KU3. Identification of Radioactive Sources and Devices for Nuclear Security** (review of key information and examples for Radioactive Sources and Devices, nondestructive identification methods, technologies and applications for nuclear security)