Program Request for

NUCLEAR ENGINEERING MINOR

Utah Nuclear Engineering Program (UNEP)

College of Engineering

The University of Utah

OCTOBER 2009

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SECTION I

The Request

With this proposal we request to establish a stand-alone Undergraduate NUCLEAR ENGINEERING MINOR offered by the Utah Nuclear Engineering program (UNEP) and housed by the College of Engineering.

There are currently no undergraduate nuclear engineering programs offered in the state of Utah. Because there is an explosive and rapidly growing attempt in the US for developing new nuclear engineering related courses, nuclear engineering certificates or nuclear engineering minors in the programs that never had a history of teaching nuclear engineering courses or doing research in this field, we believe that the University of Utah can emerge as a leader in creating the hub for nuclear education and research in the state of Utah, and beyond. This potential is measured by the years of experience; the Nuclear Engineering Program has been recognized as a degree-awarding program since 1969; in offering core nuclear engineering undergraduate courses since the fall of 1996; and in possessing unique laboratories including one of 13 remaining university TRIGA reactors.

Increased development in the undergraduate curriculum in recent years has attracted more students to nuclear education on campus. The Center for Excellence in Nuclear Technology, Engineering and Research provided some research opportunities and funding not just for graduate students, but also for undergraduate students demonstrating interest in nuclear technology.

Over the course of the past several years, there has been a continuously increasing interest among students from different engineering disciplines in taking nuclear engineering courses that culminated in students petitioning for the undergraduate nuclear engineering minor.

Therefore, the proposed minor will offer interested students the opportunity to obtain the minor in nuclear engineering in addition to their major degree that will directly contribute to alleviating the national shortage of nuclear engineers, and prepare a group of students to pursue graduate degrees in Nuclear Engineering. In next five years, nuclear industry in the US will have to replace 48% of the current work force that will retire; 55% in next ten years.

SECTION II

Complete Program Description

The UNEP undergraduate nuclear engineering minor requires **18 credit units**, as follows:

- **FOUR CORE** courses [12 credit units]
- **TWO ADDITIONAL** courses [6 credit units] selected from a list of options **or** from the student's major that closely match the suggested subdisciplines [see below]
- The attendance of the NUCL5999/6999/7999 [0 credit units], i.e. the UNEP seminar series, is required as explained below

We allow that all 18 hours of the UNEP undergraduate nuclear engineering minor courses be used as technical electives in student's major.

The UNEP undergraduate nuclear engineering minor courses have their own subject code: **NUCL**.

Core Courses (See Appendix A for more details)

NUCL3000:	Nuclear Principles in Engineering and Science	[3 credit units]	2010
NUCL3100:	Introduction to Neutron-Based Engineering	[3 credit units]	2011
NUCL3200:	Radiochemistry with Laboratory, I [cross-listed with CHEM3200]	[3 credit units]	2010
NUCL4000:	Nuclear Engineering & Science Using TRIGA	[3 credit units]	2010
NUCL5999/6999/7999:	UNEP Seminar Series	[0 credit units]	2009

Optional Courses offered by UNEP in next two years (See Appendix A for more details)

NUCL4200:	Radiochemistry with Laboratory, II	[3 credit units]	2011
NUCL4300:	Nuclear Bio-Medicine	[3 credit units]	2011
NUCL4400:	Nuclear Material Detections Using TRIGA, I	[3 credit units]	2010
NUCL4900:	Research in Nuclear Engineering & Science	[3 credit units]	2010
NUCL5000:	Health Physics	[3 credit units]	2011
NUCL5100:	Reactor Physics	[3 credit units]	2010
NUCL5900:	Research in Nuclear Engineering & Science	[3 credit units]	2010
NUCL6400:	Computational Reactor Physics	[3 credit units]	2011

The courses are linked to provide more depth and knowledge in five different sub-disciplines [**students enrolled in dual BS/MS program may use 5000 and above level courses toward their non-thesis MS degree**]:

Sub-discipline 1: General Nuclear Engineering & Science
Sub-discipline 2: Radiochemistry
Sub-discipline 3: Nuclear Safeguards
Sub-discipline 4: Nuclear Power
Sub-discipline 5: Nuclear Bio-Medicine

Purpose of the Minor

Recognized Need for Undergraduate Nuclear Engineering Minor

The growth in demand for nuclear energy not just in the United States but world-wide requires increased knowledge in nuclear science and technology. Nuclear scientists and engineers play a vital role in the development and implementation of current and future nuclear power reactors. Additional research is necessary in the fields of Health Physics and Radiochemistry. Understanding the health effects of radiation and nuclear activities as well as the generation and application of radiopharmaceuticals is a fast growing market. Nuclear science and engineering applications can be found not just in the power and health industries, but in military, industrial, environmental, and commercial programs around the world. Developing the insight and awareness of the basic science and engineering principles behind nuclear technologies will not only provide enhanced marketability for students graduating from the University of Utah, but also better prepare them for further studies in nuclear engineering graduate programs or careers that incorporate increased understanding of nuclear science and engineering.

There are approximately 50 general and 195 specific licensees for radioactive materials in Utah. A general licensee is an entity that acquires, uses, or possesses a generally licensed device and has received the device from the device manufacturer or by change of company ownership where the device remains in use at a particular location. A specific license is issued to entities that include medical (nuclear medicine), industrial (moisture-density gauges, well logging, industrial radiography, or flow meters), academic (research), and waste disposal licenses (land disposal or decay in storage). Those entities with a specific license have the facilities, equipment, personnel training, policies and procedures for radiation safety. Each one of these 195 licenses needs nuclear trained personnel.

Utah has a growing economy and the University of Utah is now building the nuclear engineering program to prepare for the growing need for nuclear engineers.

Undergraduate Nuclear Engineering Minor Objectives Targeting Competency Gaps

This program is built to prepare the students for nuclear engineering related jobs addressing the expectations of the 21st century nuclear industry and development in US and abroad, and in building US leadership.

The objectives are:

(a) To teach and practice nuclear engineering and science principles in an interdisciplinary core program preparing the undergraduates coming from diversified technical and science fields to directly and effectively support current human resource challenges in nuclear engineering related jobs

(b) To create a unique educational program in offering a specific set of linked courses interfacing various disciplines

(c) To produce a new generation of nuclear engineering and science undergraduates (and graduates) by revitalizing our educational program in radiochemistry, nuclear safeguards and

forensics, nuclear reactor hands-on-experience and learning, and assuring that modern technologies are part of the educational program

With this program we are targeting the following competency gaps in nuclear engineering and science education for the 21st century:

(a) Nuclear principles in engineering and science connecting the concepts in physics, quantum mechanics, radiation transport, mathematics, computational science and engineering, chemistry, environmental engineering, mechanical engineering, electrical engineering, biology and bioengineering, nuclear medicine and health physics
(b) Fundamental principles and concepts of neutron-based engineering with hands-on-experience
(c) Knowledge of importance to safeguard-related technologies, nuclear forensics and special nuclear material detections
(d) Basic knowledge and experimental learning pertaining to radiochemistry and radioactive waste engineering
(e) Theoretical, computational, and experimental understanding of reactor physics using TRIGA reactor and modern technologies

Admission Requirements

Students are required to be in good standing with the university as evidenced by official transcripts and to have passion for this study!

Any student from the College of Engineering, College of Science, College of Pharmacy, College of Mine & Earth Sciences, or College of Health may apply for an undergraduate nuclear engineering minor.

The undergraduate nuclear engineering minor is offered by the Utah Nuclear Engineering Program (UNEP) as a stand-alone minor. The minor is housed by the College of Engineering.

Students interested in the undergraduate nuclear engineering minor will be asked to complete the UNEP undergraduate nuclear engineering minor form, available in the UNEP Offices, and will be asked to obtain the signature(s) indicated in the form.

Students are required to keep their **overall GPA above 2.85** and **their Nuclear Engineering Minor GPA over 3.30**.

Student Advisement

Applications and advising files will be maintained by the Department for Civil and Environmental Engineering, because the UNEP is housed in this department.

Advisement will take place through group advisement sessions at the beginning of every semester and through individual meetings when needed. The UNEP graduate students will be assigned to assist in advising and will help with group and individual advisement sessions as needed.

The undergraduate advisors from the Departments of Chemical and Civil and Environmental Engineering, will be assisted by the UNEP Director and other UNEP associated faculty as detailed in Appendix C to help advise the undergraduate nuclear engineering minor students.

Justification for Number of Credits

The number of credit hours required for the Nuclear Engineering Minor, of 18, is consistent and in the range, with the required number of hours for a minor program across various curricula at the University of Utah. In addition, these 18 required hours are sufficient to expose the student to the fundamental ideas and material related to this topic, and still allow student interested in the minor to include it in a complete program of study regardless of major.

External Reviews and Accreditation

No external consultants were involved in the development of this program. However, internal discussions with various faculty helped in framing the minor. There are no requests for accreditation for this minor.

There are currently less than 50 universities in the United States that offer undergraduate or graduate degrees in Nuclear Engineering. The University of Utah is the only university in Utah currently providing Nuclear Engineering degrees, albeit only at the graduate level. The nearest undergraduate degrees available in Nuclear Engineering can be obtained from universities in either Nevada or Idaho. Provision of an interdisciplinary minor in Nuclear Engineering will reward students who have been demonstrating interest in the program, as well as assist in the development towards an undergraduate degree in nuclear engineering. Students' interest in this minor will demonstrate whether a major in Nuclear Engineering should necessarily become available in the future when the accreditation will be required.

Projected Enrollment

Over the course of the past several years, there has been a continuously increasing interest among students from different engineering disciplines in taking nuclear engineering courses that culminated in students petitioning for the undergraduate nuclear engineering minor. More than 20 students signed the petition and basically initiated the formation of this minor. We anticipate having 10 – 25 students in our minor core courses in first years with the expectations of doubling that number in the next five years. The growing interest from other colleges and universities in Utah points to an impressive number of undergraduate students expressing their ultimate desire to study nuclear engineering.

Expansion of Existing Program

The undergraduate Nuclear Engineering Minor is not an expansion of any existing program. The few nuclear engineering courses offered in recent years have been mainly at the graduate level.

Faculty & Staff

The UNEP is growing in faculty. We have an active announcement for assistant tenure track faculty to be hired this academic year. This will add to three faculty who can teach the core courses and majority of the optional UNEP courses. We also have a number of associated faculty who will teach some of the courses. The staff in the Department for Civil and Environmental Engineering, with help from the Department of Chemical Engineering, will provide necessary assistance in scheduling the courses and administrating the minor.

Library

The University of Utah's Marriott and Eccles Health Sciences libraries currently have materials required to offer a superior program as described in this proposal.

Learning Resources

No additional learning resources are required to support this program.

SECTION III

Program Necessity

There is a growing interest in nuclear engineering among students at the University of Utah and all other colleges and universities in the State of Utah, but there is no formal undergraduate program or minor, offered in this field in Utah. Therefore, the Nuclear Engineering Minor would meet the needs of students interested in nuclear engineering as a field of study and compliment a number of existing majors within the University of Utah such as chemical engineering, chemistry, mechanical engineering, civil and environmental engineering, electrical engineering, computer science and engineering, biomedical engineering, health sciences, pharmacology, biology, physics, astrophysics, material sciences and engineering, and medical studies, to list just a few.

Over the past few years, students have been enhancing their undergraduate education through coursework and educational opportunities provided through the Center of Excellence in Nuclear Technology, Engineering, and Research and the Utah Nuclear Engineering Program (UNEP). A percentage of these students later enter into a graduate program of study in Nuclear Engineering here at the University of Utah. A number of faculty at the College of Engineering expanded their research into nuclear engineering related disciplines, increasing involvement of students in selecting the nuclear engineering for their masters or doctoral degrees. The minor degree will better prepare our students to pursue advanced degrees, will increase the pool of students in our graduate program, and will address the national need for nuclear engineers.

The Nuclear Engineering Minor if established at the University of Utah, will draw more students into other major disciplines from the region and increase overall enrollment in respective colleges.

Labor Market Demand

Industry, national laboratories, government agencies, nuclear power plants and associated facilities, as well as the universities, are facing a huge wave of retirements. In addition, there is a renaissance in nuclear engineering related to power generation. These effects, together, are creating profitable, long-term careers for people with an education in nuclear engineering. Although the standard nuclear engineers are expected to have a college degree in nuclear engineering, the 21st century projects a demand for different profiles; more diversified and broad knowledge gained through dual degrees, such as a combination of major in any relevant discipline + minor in nuclear engineering. The job market also encourages students to complete at least a master degree in nuclear engineering.

Nuclear engineering jobs are found not only in nuclear power plants. Nuclear engineers are in demand:

- in hospitals for treating cancer
- in research labs, developing better nuclear power sources and imaging devices,
- in defense related areas
- in improving the solutions for waste management
- in safety regulations
- in medicine for cancer imaging and treatment
- in environmental protection
- in archeology.

Some recent projections for nuclear engineering jobs are:

- U.S. utilities will hire 470 nuclear engineers a year to keep up with retirement and attrition
- An additional 200 new hires per year are expected to be needed to staff reactors expected to begin operation over the next decade
- NRC projects to hire 400 nuclear engineers per year
- Westinghouse projects a need for 1000/year
- Energy*Solutions* expects hundreds of new hires in years to come

Student Demand

As already indicated in this proposal, there is a growing interest among the students at the University of Utah and other colleges and universities in the state of Utah, for nuclear engineering discipline. Over 20 students from the Department of Chemical Engineering signed a petition for nuclear engineering minor. There is a steady stream of students approaching the UNEP in anticipation for the undergraduate minor in nuclear engineering to be offered.

The minor in nuclear engineering will be the only one in the state of Utah thus attracting students from other colleges to participate in the program.

Similar Programs

There is no minor in nuclear engineering in the state of Utah. There are a few scattered courses pertaining to nuclear engineering offered at Utah State University, and an introductory course at Brigham Young University.

Collaboration and Impact on other USHE Institutions

We plan, within the next two years, to offer the core minor courses to other institutions in the state of Utah through distance education. Schools that may have enough student interest to support this are BYU and WSU.

Benefits

The University of Utah and the USHE will noticeably benefit by offering a Nuclear Engineering Minor program because it fulfills the need of the student, the ultimate customer. When students have options such as this open to them they will be more likely to stay on track in their education in the University of Utah system.

Consistency with Institutional Mission

The proposed Nuclear Engineering Minor program is consistent with and appropriate to the University of Utah mission toward undergraduate and graduate education, research and scholarship. This undergraduate program will provide high quality academic, professional and applied learning opportunities designed to advance the intellectual, cultural and economic well-being of the students who enroll in it.

SECTION IV

Program Assessment

The quality of the nuclear engineering minor courses and the overall program will be assessed as follows:

(1) By surveying the minor alumni that are out of the program for at least 1 year: these students will be asked to complete questionnaires to assess the quality of basic knowledge provided through core courses, the degree to which the minor has helped in securing employment in the nuclear engineering related jobs or enrolling in graduate program of their interest, and if completing the program has helped meet their personal or career goals. This survey and data analysis would generate the feedback for our program. It is UNEP intention to announce this as a potential collaborative thesis topic of interest to students in the College of Education.

(2) The UNEP Advisory Board (to be established in late December of 2009) will be asked to evaluate the Minor courses and the program as offered. Their feedback will be used in correcting the content of the program if found needed.

(3) The UNEP graduate students will be asked to participate in the minor in supervising the undergraduate students by creating and showing the solutions of some of the assignments for the minor courses. The graduate students will then be asked to evaluate the assignments: how difficult, how easy, how complex and how simple. A special questionnaire will be prepared for this evaluation.

(4) The UNEP instructors will have meetings at the beginning of each semester to discuss their courses tought in a previous semester. Sharing the experience about the students' response to the course content and assignments will help modify if needed the courses to be offered that semester.

Expected Standards of Performance

The minor program is created such that students will have basic knowledge of nuclear principles in engineering and science with hands-on experience as they relate to identified competency gaps in nuclear engineering field in the US: radiochemistry, nuclear safeguards and forensics, reactor physics and health physics, nuclear material detections, computational skills. A grade of C and higher is required in each program courses that will assure the basic knowledge in these areas have been achieved.

Student Assessment

Course homework, course tests on materials, and required power point presentations to peers in required courses as well as required minimum grade of C in all program courses will be adequate measure of competency.

Continued Quality Improvement

The Nuclear Engineering Minor will be internally reviewed by the UNEP faculty in consultation with graduate students participating in the courses. These reviews will collate and respond to student evaluations of the Minor's courses and curriculum, faculty perceptions of student performance and outcomes, and requests for including additional courses across undergraduate curricula. At the end of each semester, student course evaluations will be collected and analyzed in order to make adjustments to course content and instruction styles, as well as level of details in assessing what will be most important how difficult or how interesting the course content is. In addition, assessing the progress and success of the students who continue into graduate nuclear engineering program will provide additional information regarding the adequacy of training and preparation offered by the Minor.

SECTION V

Budget

Salaries and Wages –N/A
Benefits – N/A
Current Expense – none
Library – none
Equipment – none
Travel – none
TOTAL – zero

No additional resources are required, either as new funding or reallocation of existing budget. The existing UNEP faculty together with the UNEP associated faculty [http://www.nuclear.utah.edu/faculty.html] will teach the Minor courses.

Funding Sources

No additional funds will be required to develop and administer the Nuclear Engineering Minor, as current staff, materials and facilities can absorb the projected student load. One new faculty member is being recruited this year, so will be available to help with the teaching, but that hire is not dependent upon this minor being approved. Courses required for the Minor program are not currently offered but will be offered starting in Spring 2010.

Reallocation

The reallocation of funds is not needed for the implementation of Nuclear Engineering Minor.

Impact on Existing Budgets

It is possible that if there are more than 15 students per year taking undergraduate nuclear engineering courses in fulfillment of the Nuclear Engineering Minor, we may increase our budget based on increased student credit hours (SCH). However, we are not relying on these funds, nor do we currently require them for our proposed Minor, except for the NUCL3200 Radiochemistry course that is cross-listed with the CHEM3200.

Appendix A

All Program Courses

- **New Courses to be Added in Next Two Years**

NUCL3000:	Nuclear Principles in Engineering and Science	[3 credit units]	2010
NUCL3100:	Introduction to Neutron-Based Engineering	[3 credit units]	2011
NUCL3200:	Radiochemistry with Laboratory, I	[3 credit units]	2010
[cross-listed with CHEM3200]			
NUCL4000:	Nuclear Engineering & Science Using TRIGA	[3 credit units]	2010
NUCL4200:	Radiochemistry with Laboratory, II	[3 credit units]	2011
NUCL4300:	Nuclear Bio-Medicine	[3 credit units]	2011
NUCL4400:	Nuclear Material Detections Using TRIGA, I	[3 credit units]	2010
NUCL4900:	Research in Nuclear Engineering & Science	[3 credit units]	2010
NUCL5000:	Health Physics	[3 credit units]	2011
NUCL5100:	Reactor Physics	[3 credit units]	2010
NUCL5900:	Research in Nuclear Engineering & Science	[3 credit units]	2010
NUCL6400:	Computational Reactor Physics	[3 credit units]	2011

- **General Education: Not Applicable**

- **List of Core Courses at the UNEP** **Subtotal: 12**

NUCL3000:	Nuclear Principles in Engineering and Science	[3 credit units]
NUCL3100:	Introduction to Neutron-Based Engineering	[3 credit units]
NUCL3200:	Radiochemistry with Laboratory, I	[3 credit units]
[cross-linked with CHEM3200]		
NUCL4000:	Nuclear Engineering & Science Using TRIGA	[3 credit units]

All four of these courses can be counted as technical electives for student's major.

Starting Fall2009, the NUCL5999/6999/7999: UNEP Seminar Series [0 credit units], has already been offered. The students are required to attend minimum two semesters of the NUCL5999/6999/7999 during the Minor studies.

- **Brief Description of the Core Courses at the UNEP: Subtotal: 12**

NUCL3000: Nuclear Principles in Engineering & Science [3 credit units] Fall 2010

Instructor: **Tatjana Jevremovic**

Textbook: "Nuclear Principles in Engineering", 2nd Edition, Springer 2008, Tatjana Jevremovic

Additional: Interactive web site available to practice fundamental concepts in nuclear engineering and science using modern technology

Objectives:

Nuclear principles in engineering and science course will provide the students with fundamental understanding of basic principles covering the modern theory of the atomic and nucleus structure, quantum description of nuclear phenomena of interest in nuclear engineering, radiation types and interactions with matter, radioactive decay. Each of the section will address the application of learned principles thus connecting the concepts in physics, quantum mechanics, radiation transport, mathematics, computational science and engineering, chemistry, environmental engineering, mechanical engineering, electrical engineering, biology and bioengineering, nuclear medicine and health physics.

Prerequisites: Introductory courses in physics, mathematics, computer science/engineering

UNEP3100: Introduction to Neutron-Based Engineering [3 credit units] Spring 2011

Instructor: **Tatjana Jevremovic**

Textbook: "Nuclear Principles in Engineering", 2nd Edition, Springer 2008, Tatjana Jevremovic

Additional: Interactive web site available to practice fundamental concepts in nuclear engineering and science using modern technology

Objectives:

Introduction to neutron-based engineering will provide the students with fundamental understanding of basic principles of neutron interactions and neutron transport. The course will address the application of learned concepts thus connecting the concepts in physics, radiation transport, mathematics, computational science and engineering, chemistry, environmental engineering, mechanical engineering, electrical engineering. Students will learn how to use state-of-the-art numerical simulation methods to model neutron behavior in different reactors. The uniqueness of this course is that the students will model the TRIGA reactor using these state-of-the-art numerical simulation methods, visit the reactor and see how it operates, and be able to compare the numerical data with the real data thus ensuring that the student will learn fundamental principles and concepts of neutron-based engineering with the hands-on-experience.

Prerequisites: NUCL3000

NUCL3200: Radiochemistry with Laboratory, I [3 credit units] Spring 2010

Instructor: **Chuck Grissom, Chemistry**

Textbook: TBA

Laboratory: Next to TRIGA

Objectives:

Radiochemistry is almost non-existent in US and sporadically found around the world. The renaissance in nuclear engineering around the globe including the US, points toward revitalization of radiochemistry, nuclear safeguards, nuclear forensics and similar, and is

supported by major nuclear agencies and vendors. The UNEP has great possibility to become an educational hub for nuclear chemistry. This course will give the students understanding of what the radiochemistry is, where to apply, and how to become a radiochemist.

Prerequisites: PHYS 2210 & 2220, CHEM 1210 & 1220, MATH 1210 & 1220, and an introduction to engineering computing, or by the consent of Instructor

NUCL4000: Nuclear Engineering & Science Using TRIGA [3 credit units] Spring 2010[1]

Instructor: Tatjana Jevremovic and Dong-Ok Choe

Textbook: "Radiation Shielding", J Kenneth Shultis,
"Nuclear Principles in Engineering", Tatjana Jevremovic, 2nd edition
"Radiation Detection and Measurement", G. F. Knoll, 3rd edition

Laboratory: Next to TRIGA

Objectives:

Students will have nuclear reactor hands-on-experience and be able to learn important and crucial aspects of nuclear engineering and science practical applications. The set of three laboratory experiments will help students understand the vast use of neutron activation analysis, meaning of thermal neutron flux in a reactor and the techniques that are used to determine the profile of thermal flux, and the calculation of gamma dose around the reactors. Students will develop the habit and knowledge of how to protect themselves from radiation, what are the dosimeters and how to read the dose from dosimeters.

Prerequisites: NUCL3000; NUCL3100

NUCL5999/6999/79999: UNEP Seminar Series [0 credit units] Fall 2009

Instructor: Tatjana Jevremovic

Objectives:

Students signed for Nuclear Engineering Minor are required to attend the UNEP seminar series. There will be no more than four speakers per semester.

- **Optional UNEP Courses: Subtotal: 6**

Additional 6 credit units must be taken. However, student is allowed to select from the UNEP list of courses (as provided here in addition to any new or existing course that will be offered by UNEP faculty) OR from the student's major with the consent of the UNEP Director.

The UNEP optional courses to be offered in next two years:

NUCL4200:	Radiochemistry with Laboratory, II	[3 credit units]
NUCL4300:	Nuclear Bio-Medicine	[3 credit units]
NUCL4400:	Nuclear Material Detections Using TRIGA, I	[3 credit units]
NUCL4900:	Research in Nuclear Engineering & Science	[3 credit units]
NUCL5000:	Health Physics	[3 credit units]
NUCL5100:	Reactor Physics	[3 credit units]
NUCL5900:	Research in Nuclear Engineering & Science	[3 credit units]
NUCL6400:	Computational Reactor Physics	[3 credit units]

- **Brief Description of the Optional UNEP Courses: Subtotal: 6**

[1] Modernized, improved and revised 2/3rd of the CVEEN5710/6710 courses became NUCL4000. The rest of the CVEEN5710/6710 is combined with new topics into NUCL4400 and NUCL6200.

Courses to be offered in next 2 years:

NUCL4200 (or 5200): Radiochemistry with Laboratory, II [3 credit units] Spring 2011

Textbook: **Chuck Grissom, Chemistry**
Objectives: To be added
Prerequisites: NUCL3200

NUCL4300: Nuclear Bio-Medicine [3 credit units] Spring 2011

Instructor: **Scott Miller**
Textbook: TBA
Objectives:

Students will learn about the radiation interactions with human tissue, the use of radiation in medicine for imaging and diagnostics, and treatment of mainly cancer, as well as about the radiation doses in medical application of radiation.

Prerequisites: NUCL3000, NUCL3100

NUCL4400: Nuclear Material Detections Using TRIGA, I [3 credit units] Fall 2010

Instructor: **Tatjana Jevremovic with Dong-Ok Choe; with Rapiscan Laboratories**
Textbook: TBA
Objectives:

Students will have a unique opportunity to learn how to detect the nuclear materials and why that is not an easy and straightforward task. In addition, we will use the TRIGA to demonstrate some of the aspects regarding the nuclear materials detection.

Prerequisites: NUCL3000, NUCL3100, NUCL4000

NUCL4900/5900: Research in Nuclear Engineering & Science [3 credit units] Spring 2010

Instructor: **Any UNEP faculty**
Coordinator: Tatjana Jevremovic
Objectives:

Students signed for Research in Nuclear Engineering & Science are advised to split the course work in two semesters; if they start in Spring for example they should sign for 1 credit unit and in the following Fall (or even summer) for the rest of 2 credit units.

The research topics will vary between the instructors and yearly depending on the availability of the research projects and topics suitable for undergraduate students. Students are strongly encouraged to take this course and plan to present their research results at the ANS Student Conference (usually held in March or April every year). Students with the approval from their Instructors to present the research at the ANS Student Conference will be funded by the Utah ANS Chapter.

This course will be offered for the first time in Spring of 2010. Any professor can be instructor; however the coordinator of this course is the UNEP Director. The role of the coordinator is to make sure that the students are given appropriate load, research instructions and guidelines.

Available topics working with Dr. Tatjana Jevremovic (starting Spring 2010):

- Adapting the Geant4-based dose estimator for electron therapy; X-ray microbeam therapy; or proton therapy
- Develop the car battery full model using Geant4
- Develop 2D and 3D model of TRIGA using AGENT code
- Contribute in developing some of the web-based interactive tools for NUCL3100
- Learn about the FPGA acceleration approach and develop one segment of the hardware algorithm
- Parallel computing applied to computational neutronics: develop parallel version of AGENT through OpenMP, MPI (Message Passing Interface), and/or other techniques

- Application of GPU (Graphics Processing Unit) to computational neutronics: the graphics card of the new group server supports the CUDA model of NVidia; the graphics card can be used for general purpose numerical computations such as to accelerate AGENT
- Application of Geant4 for nuclear reactor modeling; Geant4 is mainly developed for physics modeling not for reactor physics: How does it work for nuclear reactor simulations? How well it compares to MCNP, which has been widely accepted for reactor simulations?

NUCL5000: Health Physics [3 credit units] Spring 2011

Instructor: **New faculty coming in 2010**

Textbook: "Radiation, and Radiation Protection", Turner, James E.,
Atoms, 2nd Edition, John Wiley & Sons, Inc. 1995. ISBN 0-471-59521-0
"Nuclear Principles in Engineering", Tatjana Jevremovic, 2nd Edition

Objectives:

This course will provide students with the overview of atomic and nucleus structure, radioactive decay and types of radiation (in condensed manner) based on NUCL3000 to build the understanding related to health physics: radiation interactions with matter in respect to human health, biological effects, regulation, instrumentations, and real-world examples.

Prerequisites: NUCL3000, NUCL3100

NUCL5100: Reactor Physics [3 credit units] Fall 2010

Instructor: **PostDoc Shanjie Xiao with Dong-Ok Choe**

Textbook: "Nuclear Principles in Engineering", Tatjana Jevremovic, 2nd Edition
"Nuclear Reactor Analysis", J. J. Duderstadt, L. J. Hamilton, 2nd Edition

Objectives:

This course will provide students with the overview of cross sections and fission process (in condensed manner) based on UNEP5200 to build the comprehensive understanding of reactor physics and its application to reactor design. The course will mainly focus on the theory of the reactor steady-state (normal) operation. Methods of neutron transport modeling will be explained: diffusion, method of characteristics, finite difference method, Sn, Pn. Some aspects of the reactor kinetics will be also introduced. Students will learn about modern methods in reactor physics and will be able to use modern technologies to visualize and estimate the neutron behavior in the reactor cores.

Prerequisites: NUCL3000; NUCL3100, or by consent of the Instructor

NUCL6400: Computational Reactor Physics [3 credit units] Spring 2011

Instructor: **PostDoc Shanjie Xiao with Tatjana Jevremovic**

Textbook: Various books and handouts

Objectives:

Computational reactor physics course consists of two parts: theoretical/numerical training in reactor physics using modern technology and the practical application by solving a real-world problem (modeling, benchmark, development, or similar). Strong computational skills are advantage. Students are expected to have their laptops for the second half of this course.

Appendix B

Program Schedule

It is recommended that students enroll in the Minor when they are sophomores or juniors, having completed introductory courses in chemistry, mathematics, physics, computer science and engineering or similar. Although, the core courses are at the level of 3000 and 4000, the content will be encouraging for students with sophomore standing coming into the program.

Ideally, students would take their courses according to the following schedule (NUCL4900 and NUCL5900[2] are highly recommended and the students can start with this research course as early as Sophomore fall semester):

Sophomore/Junior	Fall Semester	NUCL3000
Sophomore/Junior	Spring Semester	NUCL3100, NUCL3200
Junior/Senior	Fall Semester	NUCL4000, Optional
Junior/Senior	Spring Semester	Optional

Appendix C

Faculty and Staff To Be Used In Support Of Program

- **Faculty To Be Used In Support Of Program**

Full time faculty at UNEP:
Tatjana Jevremovic, PhD, Professor, Director UNEP
Dong-OK Choe, PhD, Research Assistant Professor, UNEP
[Assistant tenure track faculty will be hired by Fall 2010]

Associated UNEP faculty:
Scott Miller, PhD, Director of Radiobiology Division, Research Professor of Radiology & Radiobiology
Terry Ring, PhD, Professor of Chemical Engineering

[2] The UNEP has the unique opportunity of providing student/faculty interaction and research using a TRIGA (Training, Research, and Isotope-production – General Atomic) nuclear research reactor. Approximately 25 nuclear research reactors or assemblies are available at universities in the United States, while many of these reactors are not directly tied specifically to a nuclear educational program. There are currently less than 15 TRIGA reactors available in the United States for nuclear research opportunities. Next to TRIGA reactor the UNEP offers a good size lab space mainly for radiochemistry, radiobiology and radiation detection studies, experiments and research that will be put in use for undergraduate and graduate classes. Faculty are encouraged to use UNEP facilities and create NUCL4900/5900 topics for undergraduate students.

Charles Grissom, PhD, Professor of Chemistry
James J. Thompson, PhD, Adjunct Professor, Civil & Environmental Engineering; Manager, Radioactive Waste & Nuclear Materials Disposition Department at Sandia National Lab
[more faculty will be joining the UNEP in coming year]

- **Staff To Be Used In Support Of Program**

Civil and Environmental Engineering and Chemical Engineering Departments will provide necessary staff support of the Minor program.