COURSE SYLLABUS – J-Term 2017
Nuclear Research Reactor Practicum / NPTG 8506A -F16/ 2 Credit

Monday, January 16, 2017 to Friday January 27, 2017 at the Czech Technical University Prague, Czech Republic and IAEA, Vienna Austria

George M. Moore, PhD JD
Office Location: CNS Building, 2nd Floor
Office Hours (Wednesdays and Thursdays 10:00- 11:00, or by appointment)

COURSE DESCRIPTION

The practicum is organised within the framework of the newly established partnership between the James Martin Center for Non-proliferation Studies, Institute of International Studies at Monterey (MIIS) and the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague, Czech Republic (CTU).

The objective of this educational course is to give to students the basic theoretical information about safe and secure operation of nuclear installations focusing on research reactors and nuclear power plants.

COURSE OBJECTIVES

All aspects of safe and secure reactor operation are covered in the course; nuclear safety, radiation protection, emergency preparedness, security and safeguards will be covered in the practicum. Key elements of the course are hands-on activities at the Training reactor VR-1 where students can experience theoretical knowledge being put into practice at a real nuclear installation. The course includes technical visits to several nuclear installations, companies and/or state institutions, providing a comprehensive overview to students about safe and secure operation of nuclear installations.

The course is aimed to students with little or no nuclear experience who have only basic knowledge of atomic and nuclear physics.

Students successfully completing this workshop will be able to:

- Demonstrate a basic understanding of reactor operation and control for research and power reactors.
- Demonstrate a basic understanding of the nuclear fuel cycle.
- Demonstrate a basic understanding of radioactive decay, radiation detection, neutron activation analysis, and safe preparation of radionuclides in a research reactor.

TEXTBOOKS AND OTHER MATERIALS
Required Text: There is no required text for the course. Reading assignments will be posted in a Dropbox set up for the course.

METHODOLOGY AND POLICIES

The course will be graded on a Pass/Fail basis. The grade for the practicum will be based on class attendance, participation, and the completion of in-class assignments. Therefore it is essential that each student will have read the assigned materials and be prepared to discuss them and answer related questions in class. Discussions and individual contributions are encouraged, expected, and will be considered in the grade determination as described below. Poor attendance and/or inadequate preparation or participation could result in a failing grade for the course.

ACADEMIC CONDUCT

All students will be held to all policies and procedures listed in the most current Policies and Standards Manual (PSM). This includes but is not limited to our Student Honor Code and regulations on plagiarism. A complete copy of the Policies and Standards Manual (PSM) can be found here: (http://www.miis.edu/media/view/23925/original/policy_and_standards_manual_update.pdf).

*Syllabi are subject to change by the instructor with advance notice to students*
REQUIREMENTS AND GRADING

- Your grade will be based on the following performance: Sample percentage weights

| Attendance¹ | 30% |
| Class Participation | 10% |
| Completion of Quizes/Problems | 60% |
| TOTAL | 100% |

- Although this course is Pass/Fail, in order to pass, the equivalent of a C letter grade is required. For your information the following grade ranges are given.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage Range</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>90-100%</td>
<td>Excellent</td>
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<tr>
<td>B</td>
<td>80-89%</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>70-79%</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>D</td>
<td>60-69%</td>
<td>Poor</td>
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<tr>
<td>F</td>
<td>0-59%</td>
<td>Fail</td>
</tr>
</tbody>
</table>

Grades will be awarded with plus and minus designations when the student’s numerical score is in the very top or bottom end of the grade ranges described above. As noted, quality points are assigned as follows:

P (Pass) Credit for course, no grade points.
NP (No Pass) No grade points or credit.
I (Incomplete) No grade points or credit.
W (Withdrawal with permission) No grade points or credit.
AU (Audit) No grade points or credit.
IP (In Progress) No grade points or credit.

There is no other system of grading or grading category at the Monterey Institute other than those listed above.

Except for grades of “I” and “IP,” (see sections 5.3 and 5.4 in Policies and Standards Manual) all grades are considered final when reported by a faculty member at the end of a semester or marking period. A change of grade may be requested only when a calculation, clerical, administrative, or recording error is discovered in the original assignment of a course grade or when a decision is made by a faculty member to change the grade as a result of the disputed academic evaluation procedure (see section 5.2 in Policies and Standards Manual). Grade changes necessitated by a calculation, clerical, administrative, or recording error must be reported within a period of six months from the time the grade is awarded. No grade may be changed as the result of a reevaluation of a student’s work or the submission of supplemental work following the close of a semester or marking period. The Records Office shall only accept permissible changes of grade upon written approval of the faculty member’s dean, who shall first verify that the Change of Grade request satisfies legitimate criteria.

¹ The Attendance grade is defaulted to the maximum value of 5%. Failure to attend more than 3 classes without the permission of the instructor will lower this to 0%.
SCHEDULE

The program of the course consists of 28 modules split into four parts – A. General issues, B. Theoretical lectures, C. Hands-on training and D. Technical visits.

Part A - General issues

**CTU-01 - Welcome meeting**
The course opening, course goals & scope, logistics and organisational issues, short presentation of the Czech Technical University and the Department of Nuclear Reactors. The course pre-test.

**CTU-02 – Post-test**
The course post-test.

**CTU-03 - Evaluation meeting**
The course evaluation, the analysis of pre-test’s and post-test’s results, feedback discussion and closing of the course.

Part B – Theoretical lectures

**CTU-04 – How does a nuclear reactor work?**
How nuclear reactor works (basic principles of research reactor operation) - basic phenomena and principles, essential parts of a nuclear reactor, nuclear fuel and relevant parts of nuclear fuel cycle of a nuclear reactor.

**CTU-05 – Construction and operation of research reactors**
Research reactors classification, research reactors utilisation, low power research reactors, medium power research reactors, high power research reactors, operation of a research reactor.

**CTU-06 – Construction and operation of nuclear power plants**
Current, latest and future nuclear power plants designs (Gen II, III and IV), small and modular reactors and general operation of a nuclear power plant.

**CTU-07 – Nuclear installation - front and back end of the nuclear fuel cycle**
Nuclear fuel cycle, front and back end of the nuclear fuel cycle, uranium mine, enrichment plant, fuel fabrication plant, spent fuel interim storage, final disposal of nuclear fuel, fuel reprocessing plant, transport of nuclear materials, transport and storage casks.

**CTU-08 - Introduction to safe and secure operation of nuclear reactors**
3S concept of safe and secure operation of nuclear reactors (safety, security, safeguards), life cycle of research reactors, key players in the world of research reactors, basic principles of safety of research reactors, the safety principles, defence in depth, five levels of defence in depth, example of defence in depth.

**CTU-09 – Radiation protection and radioactive waste management**
Radiation sources in the environment and in a nuclear reactor, basic principles of radiation protection, ALARA principle, personal monitoring, environmental monitoring, and radioactive waste management in the operation of nuclear installation.

**CTU-10 – Emergency preparedness at a nuclear reactor**
Emergency preparedness and emergency exercises, goals of emergency response categories of nuclear and radiation installations related threats, criteria for determining emergency threat for facilities, nuclear emergency, radiological emergency, emergency preparedness at VR-1 Reactor
CTU-11 – Nuclear security at a nuclear reactor
Basic principles of security at a nuclear reactor, principle of the physical protection system, its objectives, design, analysis & evaluation – detection, delay, response, intruders – outsider vs. insider, vital areas.

CTU-12 – Safeguards at a nuclear reactor
History of safeguards, IAEA from history to today, non-proliferation treaty, comprehensive safeguards agreements, additional protocol, nuclear material accountancy and control at a nuclear reactor, inspections.

Part C – Hands-on activities

CTU-13 - Neutron detection in practice
Radiation detection, basic principles of neutron detection, set-up of neutron detection system, neutron detection in the core of the reactor, neutron flux distribution measurement in the core.

CTU-14 – Delayed neutrons in practice
Role of prompt and delayed neutrons in safe reactor operation, delayed neutron detections and measurement of its characteristics, use of delayed neutrons in detection of nuclear material in samples – measurement of U-235 content in unknown sample.

CTU-15 – Nuclear safety in practice
Reactor in critical, subcritical and supercritical state under various conditions, reactor with and without feedback, measurement of basic core safety parameters, temperature and void reactivity coefficients and its role in safe reactor operation.

CTU-16 - Reactor operation in practice
Practical training at the reactor operation, hands-on experience with reactor operation by all course participants, start-up of the reactor, increasing and decreasing the reactor power, safe shut-down of the reactor.

CTU-17 - Radiation monitoring in practice
Hands-on experience with the radiation protection and radiation monitoring in the reactor hall, personnel monitoring, monitoring of dose rate in the reactor hall in various positions and at the various reactor power levels.

CTU-18 - Nuclear security in practice
Hands-on experience on nuclear security at the VR-1 reactor.

CTU-19 - Safeguards in practice
Hands-on experience on safeguards at the VR-1 reactor.

CTU-20 - Neutron activation analysis in practice
Hands-on experience with the neutron activation analysis, basic principle of the neutron activation analysis, use of neutron activation analysis in everyday life, sample irradiation in the reactor, analysis of the samples at detection system, determination of the composition of the samples

Part D - Technical Visits

CTU-21 - VR-1 research reactor
Visit of the VR-1 research reactor (low power pool type reactor, 1 KW) at Czech Technical University in Prague, VR-1 reactor utilization and its experimental facilities, D-D neutron generator and its utilization.

CTU-22 - LVR-15 research reactor
Visit of the LVR-15 research reactor (multipurpose high power tank type reactor, 10 MW,) at Research Centre Rez, LVR-15 reactor utilization and its experimental facilities.

**CTU-23 - LR-0 research reactor**
Visit of the LR-0 research reactor (zero power pool type reactor, NPP fuel characteristics experiments) at Research Centre Rez, LR-0 reactor utilization and its experimental facilities.

*CTU-24 – SURO – National radiation protection institute* *(optional in case of not travelling to Vienna)*
Visit of the SURO – National radiation protection institute – national system for urgent actions in the case of radiological or nuclear accidents, national regulatory body emergency centre, whole body counter, etc.

**CTU-25 - Temelin /Dukovany nuclear power plant**
Visit of the Temelin nuclear power plant (WWER-1000, PWR, 2x1000 MWe) or the Dukovany nuclear power plant (WWER-440, PWR, 2x500 MWe).

*CTU-26 - Skoda Nuclear machinery* *(optional in case of not travelling to Vienna)*
Visit of the Skoda Nuclear machinery in Pilsen – heavy components course, reactor inner parts course and I&C course, transport and storage casks CASTOR.

### 6. COURSE SCHEDULE (TENTATIVE)

**a. Version of the schedule without visit to Vienna/IAEA**

<table>
<thead>
<tr>
<th>week 1</th>
<th>Mon Jan 16</th>
<th>Tue Jan 17</th>
<th>Wed Jan 18</th>
<th>Thu Jan 19</th>
<th>Fri Jan 20</th>
<th>Sat-Sun Jan 21-22</th>
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<tbody>
<tr>
<td>Morning 9-12</td>
<td>CTU-01</td>
<td>CTU-06</td>
<td>CTU-22</td>
<td>CTU-25</td>
<td>CTU-26</td>
<td>Culture program</td>
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<tr>
<td></td>
<td>CTU-04</td>
<td>CTU-07</td>
<td>CTU-23</td>
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<tr>
<td>Afternoon 13-16</td>
<td>CTU-05</td>
<td>CTU-08</td>
<td>CTU-24</td>
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<td></td>
<td>CTU-21</td>
<td>CTU-10</td>
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<table>
<thead>
<tr>
<th>week 2</th>
<th>Mon Jan 23</th>
<th>Tue Jan 24</th>
<th>Wed Jan 25</th>
<th>Thu Jan 26</th>
<th>Fri Jan 27</th>
<th>Sat-Sun Jan 28-29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning 9-12</td>
<td>CTU-13</td>
<td>CTU-09</td>
<td>CTU-11</td>
<td>CTU-16/CTU-20**</td>
<td>IAEA/CTBTO Visits in Vienna</td>
<td>Return back to the USA</td>
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<tr>
<td></td>
<td>CTU-14</td>
<td>CTU-18</td>
<td>CTU-12</td>
<td></td>
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<tr>
<td>Afternoon 13-16</td>
<td>CTU-15</td>
<td>CTU-17</td>
<td>CTU-19/IAEA*</td>
<td>CTU-02 and then Travel to Vienna</td>
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* eventual nuclear inspection from IAEA inspector, still to be determined.
** students split into two groups and work in parallel, all students attend both topics.

| General issues | Theoretical lectures | Hands-on activities | Technical visits | Culture program |

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7. COURSE LOGISTICS

Reactor location
The VR-1 reactor is located in the northern part of Prague easily reachable by taxi or public transport from the historical city centre (15-20 minutes).

Course materials
Set of course materials in English will be available for all participants and will be placed in the practicum Dropbox.

Computers and Internet connection
During the course, lecture room will be available for participants equipped with enough computers (English Windows OS with Microsoft Office) connected to the Internet. Also participants can connect to our wireless internet.

Site visits
All technical visits will be organised by CTU staff.

Lunch & Refreshment
Lunches are available at the cafeteria within the university campus (for very affordable prices). Tea and coffee will be provided by reactor staff during shorts coffee breaks in in the university campus.

Culture program
Reactor staff will organize sightseeing tour in the old Prague quarters (Prague castle, Charles bridge, Old-town square, etc.) or tour to the famous Karlstejn castle upon the request.

Transport from hotel to the reactor
Walking distance from the hotel to the reactor site.

Public transport
Wide network of metro, tram & bus lines is the best way to reach any place in Prague quickly and comfortably. The network is owned by Prague Public Transport Company. It is necessary to buy single-trip ticket in advance and the ticket should be marked in the vehicle (tram, bus or in the entrance of the metro). Reactor staff could arrange long-term tickets for the whole course (all metro, tram & bus lines) upon request.

Transportation between Vienna and Prague
The most comfortable way is via train, it takes exactly 4 hours from Prague to Vienna. One return ticket is around 40-50 EUR per person (when buying in advance), there are options for reduce fares for student groups. There are buses as well, less comfortable but one return ticket is between 30-40 EUR.

Taxi
If necessary, it is cheaper and more reliable to order taxi by telephone (for example 14014 for AAA Taxi).

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Visa
Citizens of the USA don’t need visa for visit Czech Republic.

Medical insurance
CTU does not guarantee any health insurance for the course participants. Reactor staff can arrange the medical insurance for urgent first aid with the co-operation of health insurance company upon request.

Currency and rate
Czech currency is CZK - koruna (crown), 1 koruna = 100 haleru. Rates as at August 2016: 1 USD ~ 23,50 CZK. In the city centre there are plenty of exchange offices where you can exchange money. Common credit cards are accepted mostly in the hotels, restaurants and shopping centres.