Nuclear Security Science

ENU 4370
Class Periods: M Periods 8-10 (1500-1800)
Location: MAEB 0229
Academic Term: Spring 2023

Instructor:
Prof. Kyle C. Hartig, kyle.hartig@ufl.edu
Office: 352-392-4907
Office hours: TBD (minimum two hours per week)

No Teaching Assistant

Course Description
The nuclear fuel cycle from the perspective of nuclear forensics, security, nonproliferation, and safeguards and in the context of international nuclear policies. Nuclear threats are balanced with the past history of nuclear weapons use, current nonproliferation technology, and the growth of the international nuclear industry. Signatures including radiological and morphological characteristics of nuclear material is introduced as well as the techniques for the detection of special nuclear materials.

Statement Related to Policy for Co-Listed Graduate/Undergraduate Courses
Students enrolled in the graduate course (ENU 6375) will have the following requirements imposed on them in addition to those present for the undergraduate course (ENU 4370):

- Additional complexity in the form of more involved and additional cases to consider for modeling and simulation problems.
- Graduate students will be required to present a one-hour lecture on a pre-approved special topic related to the nuclear fuel cycle and will be assessed based on a jointly developed rubric.
- Graduate students will have additional problems and/or more challenging problems on assigned homework, quizzes, and exams.
- Graduate students will be responsible for learning and implementing advanced simulation and modeling codes to solve problems in assigned projects, homework, and exams.
- Graduate students will be assessed on more demanding performance criteria on individual assignments (i.e., implement advanced numerical methods and modern programing methods and professional document preparation) as well as for the overall course outcomes.

All students in the co-listed courses will be held to the same standards regarding attendance, academic honesty, and general class expectations.

Course Pre-Requisites / Co-Requisites
ENU4605 Radiation Sources and Interactions

Course Objectives

- Provide students with the opportunity to learn the principals of radiation interactions with matter;
- Identify and discuss different elemental and isotopic analysis techniques and characteristics of different instruments;
- Obtain fundamental and applied experience in error analysis and propagation;
- Demonstrate a fundamental understanding of the nuclear fuel cycle;
- Demonstrate knowledge related to the fundamentals of nuclear weapon design and effects as well as the chronology of weapon testing by the U.S and other countries;
- Identify and evaluate nuclear forensic signatures of interdicted materials and post-detonation debris, as well as signatures of interest for safeguard verification;
- Identify risk in the nuclear fuel cycle and present historical examples of illicit trafficking or proliferation.

- Discuss the relevance of U.S. law and international agreements put in place to reduce these risks (treaties, export controls);
- Development of communication skills including technical writing and oral presentations;
- Prepare students for independent research and/or design projects through preparation of research proposals, research and instructional lectures, research papers, etc.

Materials and Supply Fees
none

Required Textbooks and Software
- K. Moody, I. Hutcheon, and P. Grant, Nuclear Forensics Analysis, Second Edition, CRC Press, 2014 (ISBN 978-1439880616).
- J. Doyle, Nuclear Safeguards, Security, and Nonproliferation: Achieving Security with Technology and Policy (ISBN 978-0750686730).
- Chart of Nuclides: You will need access to a chart of nuclides during the course. Feel free to use any one of the numerous resources available (so long as it is accurate).

Recommended Materials
- G. Knoll, Radiation Detection and Measurement, Wiley, Fourth Edition, 2010 (978-0470131480).
- Kenneth S. Krane, Introductory Nuclear Physics, Third Edition, 1988, John Wiley & Sons (978-0471805533).
- Joseph R. Parrington, et al., Nuclides and Isotopes, 15th Ed., Lockheed Martin/GE Nuclear, 1996.
- http://atom.kaeri.re.kr (chart of nuclides).

Other online and print resources will be given out during lecture and on the Canvas site.

Course Schedule *(subject to change at instructor's discretion)*

Week	Topics
1	Introduction. Syllabus. Exercise and Discussion.
2	Fundamental concepts and nuclear nonproliferation, forensics, safeguards, and security organizations/government structure and policy. Physical basis of nuclear security. Nuclear smuggling/trafficking case studies and political perspective. Proliferation (counter/non) - treaties. Nuclear deterrence.
3	Engineering issues, chemistry and nuclear forensic science. Nuclear fuel cycle and principals of nuclear explosive devices. Physics review - fission yields, decay chains, etc.
4	SNM signatures. Review of nuclear detection techniques. Passive detection techniques. Active detection techniques. Gamma Detection. Techniques for small signatures. Statistics!
5	Chronometry fundamentals, techniques, and spoofing. Uranium ore/oxide signatures - U extraction technology/signatures of uranium ore concentrates.
6	Enrichment signatures - Enrichment technologies and treaties (FMCT) and enrichment verification (signatures and challenges). JCPOA discussion. Introduction to radiochemistry.

Week	Topics
7	Fuel signatures (fresh and reprocessed) - Processing/Reprocessing Nuclear Fuel - Pu disposition and signatures of processed/reprocessed nuclear material.
	Spring Break
8	Reactor signatures (fresh and reprocessed) - reactor types - international, reactor isotopic signatures (Pu), burnout verification. Mathematical methods and machine learning. ORIGEN ARP Intro and Demo
9	In-field radioactive detection including NDA techniques. Laboratory based analysis techniques. Inferred production estimates. Communication of results.
10	Collateral forensic indicators: non-radiological and traditional forensics. Radiochemical procedures and analysis techniques. Inorganic, organic, and isotopic sample preparation.
11	Nuclear Weapons (history → effects) History of Manhattan Project, Nuclear Explosive Devices - technology and classification
12	Nuclear force structure (US and International), nuclear weapon effects (fireball physics, debris formation, signatures, etc.).
13	Post detonation signatures - overview/challenges/data needs, environmental sampling and analysis techniques, CTBT - radioxenon/seismic signatures, AFTAC.
14	Materials fingerprints: predictive and comparative signatures. Source and route attribution. Attribution.
15	Final Lecture – Special Topics
	Final Exam

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance Policy. Students should attend each class period as quizzes will occur during the lecture period sporadically throughout the semester. For pre-approved excused absences for days where a quiz occurs, make-up quizzes will be made available. If the student must miss a class for an appropriate reason, it should be brought to the attention of the instructor as far in advance as possible. In the event of an unexcused absence, it is the student's responsibility to obtain and review the material that was covered during that class period.

Excused absences are consistent with university policies in the undergraduate catalog https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx and require appropriate documentation.

Evaluation of Grades

Assignment	Total Points	Percent of Course Grade
Discussion/Participation	100	10%
Homework	200	20%
Quizzes	50	5%
Project (1)	150	15%
Project (2)	200	20%
Exam	200	20%
Final Exam	100	10%
Total	1000	100%

Grading Policy

Percent	Grade	Grade Points
92 – 100	A	4.00
88 – 91.9	A-	3.67
84 – 87.9	B+	3.33
80 – 83.9	B	3.00
76 – 79.9	B-	2.67
72 – 75.9	C+	2.33
68 – 71.9	C	2.00
65 – 67.9	C-	1.67
62 – 64.9	D+	1.33
59 – 61.9	D	1.00
56 – 58.9	D-	0.67
0 – 55.9	E	0.00

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Project Description: The projects will allow you to apply the fuel cycle and nuclear security science theory you have learned in the course and assess how well you have learned the theory. Modern and industry standard fuel cycle and detector simulation and modeling codes will be used to accomplish assigned objectives representing real-world nuclear security problems. Projects will consist of both individual and group efforts that will result in moderate (~10-25 page) reports and at least one associated presentation.

Discussion & Participation Description: You will be graded on your participation and discussion in the course. This activity will consist of several Kahoot in-class surveys/interactions as well as in-class "flipped classroom" style worksheets and discussion topics. If an in-class discussion or participation assignment is missed, you will be able to make-up these assignments through a Canvas based recorded response to the same or similar topic and/or

worksheet (small changes may be necessary due to completion of makeup work being a primarily individual task and in-class activities in this category being a primarily small-group experience).

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment
The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:
• Your academic advisor or Graduate Program Coordinator
• HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*:* https://distance.ufl.edu/getting-help/; *https://distance.ufl.edu/state-authorization-status/#student-complaint*.