The University of Florida, Department of Materials Science and Engineering
Nuclear Engineering Program

ENU 6375: Nuclear Security Science
Class Periods: M Periods 8-10 (1500-1800)
Location: WEIL 0234
Academic Term: Spring 2026

Instructor: Prof. Kyle C. Hartig, kyle.hartig@ufl.edu
210 MAE; 352-392-4907
Office hours: TBD

Note: Office hours will be offered in my office. Office hours may change due to conflicts (e.g., upcoming travel schedule) and will be scheduled the first week of class.

Note: For all course-related questions a preferred mode of interaction is to visit with the professor during office hours or during class and refrain from using email.

Teaching Assistant: None.

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.

This course culminates in a submission-ready manuscript. Journal submission is optional; a no-submission alternative of equal weight is available. Authorship follows community standards: only those who make substantial scholarly contributions, participate in drafting/revision, approve the final version, and accept accountability will be authors, with order reflecting contributions and academic conventions. Grades are independent of journal acceptance and of authorship decisions. Publication fees, if any, will not be borne by students.

Course Pre-Requisites / Co-Requisites
Departmentally Controlled: Instructor Approval; ENU6051 strongly suggested

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, 2019 (ISBN 978-0128032718).
- 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). http://atom.kaeri.re.kr (chart of nuclides).
- MCNP 6.3.1, GADRAS, and SCALE available for free by request on RSICC (https://rsicc.ornl.gov/Default.aspx) See canvas page for details.

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).
- James E. Turner, Atoms, Radiation and Radiation Protection, 3rd ed., 2007 (978-3527406067). Free PDF: https://onlinelibrary.wiley.com/doi/book/10.1002/9783527616978
- J. Kenneth Shultis & Richard E. Faw, Fundamentals of Nuclear Engineering, 3rd ed., 2016 (978-1498769297).

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

Week	Topics
Jan. 12	Introduction. Syllabus. Exercise and Discussion. Fundamental concepts and nuclear nonproliferation, forensics, safeguards, and security organizations/government structure and policy. Physical basis of nuclear security. Project 1 Assigned
Jan. 26	Engineering issues, chemistry and nuclear forensic science. Nuclear fuel cycle and principals of nuclear explosive devices. Physics review - fission yields, decay chains, etc. Project 1 Check-In (concept approved by Dr. H)
Feb. 2	SNM signatures. Review of nuclear detection techniques. Passive detection techniques. Active detection techniques. Gamma Detection. Techniques for small signatures. Statistics!
Feb. 9	Chronometry fundamentals, techniques, and spoofing. Uranium ore/oxide signatures - U extraction technology/signatures of uranium ore concentrates.
Feb. 16	Enrichment signatures - Enrichment technologies and treaties (FMCT) and enrichment verification (signatures and challenges). JCPOA discussion. Introduction to radiochemistry. Project 2 Assigned
Feb. 23	Fuel signatures (fresh and reprocessed) - Processing/Reprocessing Nuclear Fuel - Pu disposition and signatures of processed/reprocessed nuclear material. Project 1 Due
Mar. 2	Reactor signatures (fresh and reprocessed) - reactor types - international, reactor isotopic signatures (Pu), burnout verification. Mathematical methods and machine learning. MCNP and GADRAS Intro and Demo Exam
Mar. 9	Spring Break

Week	Topics
Mar. 23	In-field radioactive detection including NDA techniques. Laboratory based analysis techniques. Inferred production estimates. Communication of results. Grad Lectures – Two Groups
Mar. 30	Collateral forensic indicators: non-radiological and traditional forensics. Radiochemical procedures and analysis techniques. Inorganic, organic, and isotopic sample preparation. Grad Lectures – Two Groups
Apr. 6	Nuclear Weapons (history → effects) History of Manhattan Project, Nuclear Explosive Devices - technology and classification Nuclear force structure (US and International), nuclear weapon effects (fireball physics, debris formation, signatures, etc.). Grad Lectures – Two Groups Project 2 Check-In
Apr. 13	Post detonation signatures - overview/challenges/data needs, environmental sampling and analysis techniques, CTBT - radioxenon/seismic signatures, AFTAC. Grad Lectures – Two Groups
Apr. 20	Materials fingerprints: predictive and comparative signatures. Source and route attribution. Attribution. Final Lecture – Special Topics Project 2 Due
Apr. 27	**Final Exam**

Evaluation of Grades

Assignment	Total Points	Percent of Course Grade
Homework	300	30%
Project (1)	200	20%
Project (2)	350	35%
Exam	75	7.5%
Final Exam	75	7.5%
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 the UF graduate school grading policy may be found at:
https://gradcatalog.ufl.edu/graduate/regulations/

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.

Academic Freedom, Respectful Discourse, and Sensitive Topics
The University of Florida is committed to open inquiry and the free exchange of ideas. In this course, that commitment is essential: studying nuclear security requires frank discussion of complex science, policy, ethics, and geopolitics. Students and instructors may express, examine, and challenge ideas—popular or unpopular—consistent with UF regulations and applicable law.

We value civility and professionalism. Civility does **not** require agreement, silence, or adherence to any particular framing of issues. It **does** require that we engage one another in the proper currency of academic work: reasons, evidence, and clear arguments. No ideas or positions are out of bounds for critical examination, with the obvious exceptions of advocating violence, intimidation, or unlawful activity, and any conduct that violates UF's Non-Discrimination/Harassment and related policies.

Because free expression is honored in this class, there is no "thought" or "language" policing. You may vigorously question and debate. You may not personally attack, demean, or harass. Expect discussion of controversial topics; our goal is to scrutinize arguments and evidence in the pursuit of truth and better policy, not to avoid discomfort.

Subject-matter note for this course: We will not handle classified information. Technical or operational details that could reasonably facilitate harm will not be shared or solicited. Discussion will rely on publicly available sources and will comply with export-control and other applicable laws.

If you have concerns about classroom climate or a specific interaction, please raise them with the instructor promptly; you may also use UF's established reporting and support channels.

Attendance
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 graduate handbook and require appropriate documentation.

Required Computer
Recommended Computer Specifications: https://it.ufl.edu/get-help/student-computer-recommendations/
HWCOE Computer Requirements: https://www.eng.ufl.edu/students/advising/fall-semester-checklist/computer-requirements/

Use of AI Tools
Generative-AI platforms (e.g., ChatGPT, Grok, GitHub Copilot, Claude) may be used in this course for idea generation, editing, debugging, or study support, provided you: (1) evaluate and verify all content the tool produces, (2) ensure the final submission represents your own understanding and analytical effort, and (3) disclose any substantive AI assistance (tool, date, and purpose) in a brief footnote or code comment. Unattributed or wholesale adoption of AI output, or use that circumvents learning objectives, constitutes academic misconduct under the UF Honor Code. Remember that AI models can fabricate references, misstate facts, and reproduce copyrighted or biased material; you are responsible for the accuracy, originality, and

ethical integrity of everything you submit. Questions about appropriate use will be discussed in class as AI capabilities and university guidance evolve.

Academic Policies & Resources

To support consistent and accessible communication of university-wide student resources, instructors must include this link to academic policies and campus resources: https://go.ufl.edu/syllabuspolicies. Instructor-specific guidelines for courses must accommodate these policies. Graduate level grading and attendance policy: https://gradcatalog.ufl.edu/graduate/regulations/

Commitment to a Positive 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.

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 Coordinator
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@ufl.edu