

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

ENU 4930: Nuclear Security Science

Spring Semester 2019

Catalog Description: This course explores the nuclear fuel cycle from the perspective of nuclear forensics, security, and safeguards and in the context of current international nuclear policies. Nuclear threats are balanced with the past history of nuclear weapons use, current nonproliferation technology, and the future international growth of the nuclear industry. Critical thinking will be assessed by way of (but not limited to) in-class discussions, journal article reviews, written analysis of fuel cycle signatures, and conducting research. Signatures including radiological and morphological characteristics of nuclear material is introduced as well as the techniques for the detection of special nuclear materials. Guest lectures and laboratory exercises will be included and dispersed throughout the duration of the course.

Credit: 3 hours

Instructor: Prof. Kyle C. Hartig kyle.hartig@ufl.edu
352-392-4907; 180 Rhines Hall
Office hours: Tuesday 1030 - 1130
Friday, 1000 – 1100
Office hours may change due to laboratory schedule/upcoming travel schedule

Note: For all course-related questions a preferred mode of interaction is to visit the instructor or teaching assistant in person during office hours and refrain from using email.

Teaching Assistant: N/A
Email:
Office hours:

Textbook: K. Moody, I. Hutcheon, and P. Grant, *Nuclear Forensics Analysis*, Second Edition, CRC Press, 2014 (ISBN 978-1439880616)

Recommended: 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)
Other online and print resources will be given out during lecture and on the Canvas site

Pre-requisites and Co-requisites:

Pre-requisites for ENU 4930:

- EEL 3003 Elements of Electrical Engineering
- ENU4605 Interaction of Radiation with matter
- ENU4612 Nuclear Radiation Detection and Instrumentation +Laboratory

Course Objectives:

Provide students with the opportunity to learn the principals of radiation interactions with matter; Elemental and isotopic analysis techniques and characteristics of different instruments; Error analysis and propagation; Illustrate the nuclear fuel cycle; Convey the physical fundamentals of nuclear weapon design and effects, and outline the chronology weapon testing in the U.S; 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 production of research proposals, research and instructional lectures, research papers, etc.

Relationship of Course to Program Outcomes (ABET only)

This course supports the following program outcomes:

- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic,
- (e) an ability to identify, formulate, and solve engineering problems
- (l) an ability to apply advanced mathematics, science, and engineering science, including atomic and nuclear physics, and the transport and interaction of radiation with matter, to nuclear and radiological systems and processes
- (n) an ability to work professionally in one or more of the areas of: nuclear power; nuclear instrumentation and measurements; nuclear materials; and radiation sources, shielding, and protection.

Meeting Times & Schedule:

M 1500 – 1800, Jan 7 – Apr. 23, 2019

Note: adjustments to this regular schedule could be made periodically and announced in advance in class and/or through the class website/email. Occasionally, the lecture may be recorded and the students instructed to watch a video on the course Canvas site instead of meeting for class.

Meeting Location

Lecture: Weil Hall 0238 (HWCOE Building)
Laboratory Exercises: TBA

Material and Supply Fees

None.

Web Tools: <https://lss.at.ufl.edu/>

The course Canvas site will be used to distribute the syllabus, announcements, slides, grades, etc.

I may place course notes ahead of lectures on Canvas. Canvas will also be the location to download other posted course materials, such as homework, project descriptions, worksheets, and sample problems.

Grading: Below is a breakdown for the grading in the lecture (subject to change):

- Homeworks - 20%
- Projects - 45%
- Lecture presentation - 10%
- In-class worksheets, quizzes, discussion, and participation - 15%
- Laboratory experiment(s) - 10%
- Extra Credit: (Up to 10%) Attend Nuclear Engineering Program seminars (1% each).
Form to be provided for verification.

The following grades will be assigned based on the final score: A, A-, B+, B, B-, C, D, and E. The initial grade ranges will follow the traditional high-school grade scale. Any

adjustment/curve to this grade scale will be determined at the conclusion of the course and will be based on the performance of the entire class.

Workload: The instructor is aware that senior students and new graduate students have extremely busy semesters. Reasonable accommodations on homework, projects, and requirements will be made for professional commitments (conference attendance, taking the comprehensive/proposal exam, grad school visits, etc.). Some deadlines may be moved back due to other courses.

Academic Integrity: All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others.

Disabilities: Students requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

UF Counseling Services

- Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:
- University Counseling Center, 301 Peabody Hall, 392-1575, Personal and Career Counseling.
- SHCC mental Health, Student Health Care Center, 392-1171, Personal and Counseling.
- Center for Sexual Assault/Abuse Recovery and Education (CARE), Student Health Care Center, 392-1161, sexual assault counseling.
- Career Resource Center, Reitz Union, 392-1601, career development assistance and counseling.

Schedule: (subject to adjustments throughout semester and addition of guest and student lectures)

Week	Topics	Reading
7-Jan	Introduction. Syllabus. Exercise and Discussion.	Moody Ch 1
14-Jan	Fundamental concepts and nuclear forensics and security organizations/ government structure and policy. Physical basis of nuclear forensics. Nuclear smuggling/trafficking case studies and political perspective. Proliferation (counter/non) - treaties. Nuclear deterrence.	Moody Ch 1-2
21-Jan	Holiday	
28-Jan	Engineering issues, chemistry and nuclear forensic science. Nuclear fuel cycle and principals of nuclear explosive devices. History of U.S. and international development. Physics review - yields, decay chains, etc.	Moody Ch 3-5
4-Feb	SNM signatures. Review of nuclear detection techniques. Passive detection techniques. Active detection techniques. Gamma Detection. Techniques for small signatures. Statistics!	Moody Ch 5-7
11-Feb	Chronometry fundamentals, techniques, and spoofing. Uranium ore/ oxide signatures - U extraction technology/signatures of uranium ore concentrates.	Moody Ch 6
18-Feb	Enrichment signatures - Enrichment technologies and treaties (FMCT) and enrichment verification (signatures and challenges). JCPOA discussion. Introduction to radiochemistry.	
25-Feb	Fuel signatures (fresh and reprocessed) - Processing/Reprocessing Nuclear Fuel - Pu disposition and signatures of processed/reprocessed nuclear material.	
4-Mar	Spring Break	
11-Mar	Reactor signatures (fresh and reprocessed) - reactor types - international, reactor isotopic signatures (Pu), burnout verification, ORIGEN ARP Intro and Demo	
18-Mar	In-field radioactive detection including NDA techniques. Laboratory based analysis techniques. Inferred production estimates. Communication of results.	Moody Ch 14-17
25-Mar	PNNL Laboratory Exercise.	
1-Apr	Nuclear Weapons (history → effects) History of Manhattan Project, Nuclear Explosive Devices - technology and classification, nuclear force structure (US and International), nuclear weapon effects.	
8-Apr	Post detonation signatures - overview/challenges/data needs, environmental sampling and analysis techniques, CTBT - radioxenon/ seismic signatures, AFTAC	

Week	Topics	Reading
15-Apr	Collateral forensic indicators: non-radiological and traditional forensics. Radiochemical procedures and analysis techniques. Inorganic, organic, and isotopic sample preparation.	Moody Ch 8-13
22-Apr	Materials fingerprints: predictive and comparative signatures. Source and route attribution. Attribution.	Moody Ch 18-25
29-Apr	Final Lecture - Special Topics	

Commitment to a safe and inclusive learning environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination.

It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

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
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@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@ufl.edu

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

Grade Appeal

All appeals of grades, including those from clerical/grade-calculation errors, must be made within one week of return. (This may be modified for specific assignments near the end of the term. I will announce this via e-mail as needed.)

Grade appeals must be provided in the following format:

- Include your entire assignment unmodified.
- Attach (paper clip preferred) a written summary of which problem(s) or part(s) you believe were graded inaccurately. Be as specific as possible.
- Turn in your appeal to me at class time or during office hours.

I will review your grade appeal, contact you via your ufl.edu e-mail address, and return the assignment in class. Fairly simple appeals provided to me during office hours may be decided upon while you wait, at my discretion.

Appeals will be considered for clerical errors, addition errors, and inconsistent scoring. Grade appeals will not be entertained if you simply do not like that (for example) Part 1 was worth only 2 points with Part 2 worth 5 points.

On very rare occasions, if I believe the student is not acting in a good faith belief that more points are deserved, I will deem the appeal frivolous. Following two frivolous appeals, your grade appeal privilege through this method will be revoked. Further appeals must be done through the petitions process, which requires formal paperwork and department/program level involvement.

Electronic Communication and Course Website

The primary means of communication with the class outside of class time will be e-mail listserv. These listservs will send to your @ufl.edu address only. Any inquiries regarding grading will be directed towards your @ufl.edu address only, per FERPA.

The primary use of the Canvas website is for file storage, as assignments, lecture notes, etc. may be provided there. I take no responsibility for downtime of this service, nor for actions of University of Florida staff that affect the website (including Canvas upgrades). The gradebook on Canvas is used to enable you to look up grades quickly. Note that this gradebook is not official. I reserve the right to correct errors, including transcription errors, from the official (spreadsheet) gradebook, to which I alone have access, until finalization of grades with the registrar.

Attendance

As this course meets only once per week, students are expected to attend each class period. If the student has to 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.

If a student arrives late or leaves early, he/she is expected to do so with minimum level of disruption to the class in progress. There is no tolerance for unauthorized (i.e. instructor verbal permission) mobile phone or other electronic use and/or disruptions. Such disruptions will lead to the student being told to leave the room for the duration of the class period, including during examination periods. The same principle applies to office hours or appointments – if you stop by my office and your phone rings, you will be told to leave the room for the duration of that day's office hours (or your appointment considered over).