Syllabus

Instructor:	John Mattingly 2148 Burlington Nuclear Laboratories jkmattin@ncsu.edu 919.515.0224
Office hours:	Available Monday - Friday 9:00 - 17:00 by e-mail appointment
Teaching assistant:	Faisal Rahman mrahman3@ncsu.edu Available Monday - Friday 9:00 - 17:00 by e-mail appointment
Prerequisites:	Graduate standing in Nuclear Engineering or instructor approval
Textbook:	James Doyle, editor, Nuclear Safeguards, Security and Nonproliferation: Achieving Security with Technology and Policy, ISBN: 9780750686730 Selected chapters will be provided when needed
Course credit:	3 semester hours
Course schedule:	Monday/Wednesday 10:15 – 11:30 327 Lampe All lectures will be recorded and posted to the NE541 Moodle site (see https://wolfware.ncsu.edu)
Course content:	With the global expansion of nuclear power, nuclear nonproliferation and safeguards have become major objectives of civilian nuclear power projects. The US Government has initiated an endeavor in this area under the Next Generation Safeguards Initiative (NGSI) of the Department of Energy. Human capital development is one of the main components of this initiative. This course is being offered in partnership with Oak Ridge National Laboratory (ORNL) in support of the NGSI. The objective of the course is to educate students about nuclear nonproliferation, safeguards, and security from both the policy and the technical perspectives. Students will develop an understanding of the technical and policy challenges to maintain and support a robust nuclear nonproliferation and safeguards regime. Learning objectives will be supported by assignments designed to reinforce understanding of the individual subject areas covered, class projects which cover key areas such as proliferation case studies, and interactions with subject matter experts in nuclear nonproliferation and safeguards.

Syllabus

Course objectives and assignments

Course objectives: The high-level learning objectives of this course include:

- Characterize the dynamics of nuclear proliferation in association with nuclear energy technology development and deployment.
- Describe and discuss the history, structure, strengths, and weaknesses of international nuclear nonproliferation regimes.
- Develop working knowledge of the technologies employed for nuclear nonproliferation and safeguards.
- Describe how technology and policy work together to address the issues in nuclear nonproliferation and safeguards.

Assignments:

20%	homework
20%	Q&A with guest lecturers
20%	historical proliferation case study
20%	midterm exam
20%	final exam

Assignments, like all other course materials, will be distributed via the NE541 Moodle site (see https://wolfware.ncsu.edu). Students will submit their assignments through the NE541 Moodle site.

Late assignments: Credit will be deducted from assignments that are submitted late:
≤ 24 hours late: -10% credit
24 - 48 hours late: -20% credit
48 - 72 hours late: -30% credit
> 72 hours late: no credit

Excused absences: In the event that an assignment must be submitted late due to an excused absence, advance notice is required, and the absence will be excused at the discretion of the instructor. Note that there is no means to make up the Q&A sessions with guest lecturers or the proliferation case study presentation.

Grading:

A+	97 – 100%	A	93 – 96%	A-	90 – 92%
B+	87 – 89%	B	83 – 86%	B-	80 – 82%
C+	77 – 79%	C	73 – 76%	C-	70 – 72%
D+	67 – 69%	D	63 – 66%	D-	60 – 62%
F	< 60%				

Questions for guest lecturers will be due in advance of Q&A teleconferences. Your historical proliferation case study grade will be based in part on the peer grade assigned by your case study partner(s).

Syllabus

Policies and procedures

Grade revisions:	Any requests to re-grade homework or exam solutions must be submitted in writing within 2 days after the graded assignment is returned, and the request must include a detailed justification. Requests to revise grades will not be considered after this period or without written justification. Furthermore, the entire assignment will be re-graded by the instructor.
Homework:	Each student is expected to be able to solve homework assignments independently. Students may cooperatively work on homework assignments if they want. However, the solution turned in by each student must be unique and not a copy of any other student's solution.
Exams:	The midterm and final will be open-book, take-home exams. Students may **not** work cooperatively on exams. Each student must submit an independent solution.
Attendance:	Full participation in lecture sessions, teleconferences, class projects, and exams is expected of students commensurate with University Policy. Notify me as early as possible if you can't attend class. Refer to University Policies on Attendance Regulations REG 02.20.03.

Syllabus

Plagiarism:

In this class, Turnitin is used to help students ensure that they have not plagiarized others in their written assignments. Plagiarism is a serious violation of the Code of Student Conduct; a definition appears below. Students who are found to have plagiarized on their assignment submissions will have their case referred to Student Conduct for disciplinary proceedings.

Plagiarism is the use or close imitation of the language and thoughts of another and the representation of the other's work as their own. The act of submitting work for evaluation or to meet a requirement is regarded as assurance that the work is the result of the student's own thought and study, produced without assistance, and stated in that student's own words, except as quotation marks, references, or footnotes acknowledge the use of other sources. Any ideas or materials taken from another source for either written or oral use must be fully and correctly acknowledged. Submission of work used previously must first be approved by the faculty member. Plagiarism includes, but is not limited, to the following actions:

(a) Representing the work of others as his or her own; or
(b) Submitting written materials without proper attribution or acknowledgment of the source.

Academic integrity:

Academic integrity is held in the highest regard. Academic dishonesty, cheating, plagiarism, and aiding and abetting these activities will not be tolerated. I will do everything in my capacity to ensure academic integrity in this course. It is the responsibility of every student to uphold the highest standards of academic integrity and to report any infractions of the university's policy on academic integrity. Sanctions for academic dishonesty range from reduction of assignment grades to expulsion. Refer to University Policies on Code of Student Conduct POL 11.35.01.

Accommodation:

North Carolina State University makes every effort to provide the necessary resources and accommodations for students with special needs. The NCSU Disability Resource Office coordinates resources and accommodation for students with special needs. Per University Policy, accommodations are not retroactive. If you require special accommodations, you need to self-identify with the Disability Resource Office within a reasonable amount of time to set up accommodations. Refer to University Policies on Academic Accommodation for Students with Disabilities REG 02.20.01.

Syllabus

Course activities

This course addresses the major elements of nuclear nonproliferation and safeguards in an integrated manner by:

1. Examining the issues of nuclear proliferation from the perspective of civilian nuclear power development.
2. Discussing the technologies and processes for protection, control, and accounting of nuclear materials.
3. Studying the science of detecting nuclear proliferation.
4. Integrating the preceding subjects with the goal of strengthening the global nuclear nonproliferation regime.
5. Examining the subject of nuclear nonproliferation and safeguards from a global policy perspective.

In addition to the typical pedagogical activities (lectures, homework assignments, and exams), this course includes several other activities that will give students a more interactive learning experience, including interaction with practicing professionals in nuclear nonproliferation and a capstone proliferation case study project.

Historical proliferation case studies

Students will conduct a case study based on a country that was involved in proliferative activities (e.g., Argentina, Brazil, India, Iran, Iraq, Libya, Pakistan, North Korea, or South Africa). The scenarios will be characterized by capabilities of the state (economic, industrial, and military), types and characteristics of nuclear facilities and human resources, the objectives of the proliferative activities, the types of proliferation actions, and the outcome of those actions. Each case study will develop policy lessons from the country for world nuclear nonproliferation.

Interaction with subject matter experts

Students will have opportunities to directly interact with subject matter experts representing Oak Ridge National Laboratory and the International Atomic Energy Agency (IAEA) via video teleconference.

Syllabus

Meeting schedule (subject to revision)

Week of	Date	Time	Topic	Speaker(s)
1/8/2024	1/8/2024	10:15 - 11:30	Course Introduction	John Mattingly
	1/10/2024	10:15 - 11:30	History of Nuclear Weapons Development - Part 1	John Mattingly
1/15/2024	**1/15/2024**		**No class: Martin Luther King remembrance**	
	1/17/2024	10:15 - 11:30	History of Nuclear Weapons Development - Part 2	John Mattingly
1/22/2024	1/22/2024	10:15 - 11:30	History of Nuclear Nonproliferation - Part 1	John Mattingly
	1/24/2024	10:15 - 11:30	History of Nuclear Nonproliferation - Part 2	John Mattingly
1/29/2024	1/29/2024	10:15 - 11:30	Nuclear Fuel Cycle: Front End	John Mattingly
	1/31/2024		Nuclear Fuel Reprocessing and Recycling IAEA Safeguards	Andy Worrall Jill Cooley
2/5/2024	2/5/2024	10:15 - 11:30	Requirements for Nuclear Weapons Development	John Mattingly
	2/7/2024	10:15 - 11:30	Videoconference with ORNL: - Nuclear Fuel Reprocessing and Recycling - IAEA Safeguards	 Andy Worrall Jill Cooley
	2/9/2024		**Homework 1 due at 5:00 pm**	
2/12/2024	2/12/2024	10:15 - 11:30	Radiation Detection Fundamentals - Part 1	John Mattingly
	2/14/2024	10:15 - 11:30	Radiation Detection Fundamentals - Part 2	John Mattingly
2/19/2024	2/19/2024		Uranium Enrichment Safeguards Spent Nuclear Fuel Safeguards	Michael Whitaker Cathy Romano
	2/21/2024	10:15 - 11:30	Non-destructive Analysis (NDA) using Gamma Spectroscopy and Neutron Concidence Counting	John Mattingly
2/26/2024	2/26/2024	10:15 - 11:30	Videoconference with ORNL: - Uranium Enrichment Safeguards - Spent Nuclear Fuel Safeguards	 Michael Whitaker Jianwei Hu
	2/28/2024	10:15 - 11:30	Probability / Measurement Uncertainty - Part 1	John Mattingly
	3/1/2024		**Homework 2 due at 5:00 pm**	
3/4/2024	3/4/2024	10:15 - 11:30	Probability / Measurement Uncertainty - Part 2	John Mattingly
	3/6/2024		Transportation Security Containment and Surveillance Technologies	Marc Fialkoff Chris Pickett
	3/8/2024		**Proliferation case study outlines due at 5:00 pm**	
3/11/2024	**3/11/2024 - 3/15/2024**		**No class: spring break**	
3/18/2024	3/18/2024	10:15 - 11:30	Proliferation Resistance and Safeguards - Part 1	John Mattingly
	3/20/2024	10:15 - 11:30	Videoconference with ORNL: - Transportation Security - Containment and Surveillance Technologies	 Kevin Connolly/Marc Fialkoff Nathan Rowe
	3/22/2024		**Midterm exam due at 5:00 pm**	
3/25/2024	3/25/2024	10:15 - 11:30	Proliferation Resistance and Safeguards - Part 2	John Mattingly
	3/27/2024	10:15 - 11:30	Nuclear Weapons Strategy	Robert Reardon
4/1/2024	4/1/2024		Nuclear Export Controls Post-Detonation Nuclear Forensics	David Snider Vince Jodoin
	4/3/2024	10:15 - 11:30	Negotiating Nuclear Nonproliferation Policy	William Boettcher
	4/5/2024		**Homework 3 due at 5:00 pm**	
4/8/2024	4/8/2024	10:15 - 11:30	Videoconference with ORNL: - Nuclear Export Controls - Post-Detonation Nuclear Forensics	 Brian Starks Vince Jodoin
	4/10/2024		**Proliferation case study reports and briefings due at 5:00 pm**	
4/15/2024	**4/15/2024** **4/17/2024**	**10:15 - 11:30**	**Historical Proliferation Case Study Briefings**	**Students**
4/22/2024	4/22/2024	10:15 - 11:30	Re-examining the NPT	John Mattingly
	4/22/2024		**Final exam due at 5:00 pm**	

In-class meeting (327 Lampe)
Recorded lecture; link provided on Moodle site
Video teleconference (327 Lampe); link provided on Moodle site

Syllabus

Resources

History of nuclear nonproliferation

- Thomas C. Reed, Danny Stillman, *The Nuclear Express: A Political history of the Bomb and its Proliferation*, Zenith Press, 2009.
- Sarah .J. Diehl and J. Clay Moltz, *Nuclear Weapons and Nonproliferation*, ABC-CLIO, Inc., 2002.
- Joseph Cirincione, *Deadly Arsenals*, Carnegie Endowment for International Peace, 2002.
- The History of Nuclear Energy, US Department of Energy, http://energy.gov/sites/prod/files/The%20History%20of%20Nuclear%20Energy_0.pdf
- History of Nuclear Energy, World Nuclear Association, http://www.world-nuclear.org/info/inf54.html
- Volha Charnysh , "A Brief History of Nuclear Proliferation," Nuclear Age Peace Foundation, https://www.wagingpeace.org/wp-content/uploads/2012/11/Proliferation_History.pdf

Nuclear nonproliferation regime

- Man-Sung Yim, "Nuclear nonproliferation and the future expansion of nuclear power," *Progress in Nuclear Energy* Vol. 48, pp. 504-524, 2006
- George Bunn, "The Nuclear Nonproliferation Treaty: History and Current Problems," http://www.armscontrol.org/act/2003_12/Bunn
- Treaty on the Non-proliferation of Nuclear Weapons, INFCIRC/140, IAEA, http://www.iaea.org/publications/documents/infcircs/treaty-non-proliferation-nuclear-weapons
- The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-proliferation of Nuclear Weapons, INFCIRC/153, IAEA, http://www.iaea.org/publications/documents/infcircs/structure-and-content-agreements-between-agency-and-states-required-connection-treaty-non-proliferation-nuclear-weapons
- Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards, INFCIRC/540, IAEA, http://www.iaea.org/publications/documents/infcircs/model-protocol-additional-agreements-between-states-and-international-atomic-energy-agency-application-safeguards
- Zannger Committee Trigger List, INFCIRC/209, IAEA, https://www.iaea.org/publications/documents/infcircs/communications-received-members-regarding-export-nuclear-material-and-certain-categories-equipment-and-other-material
- Nuclear Suppliers Group, INFCIRC/254, IAEA, http://www.iaea.org/publications/documents/infcircs/communications-received-certain-member-states-regarding-guidelines
- Fritz Schmidt, "NPT Export Controls and the Zannger Committee," *The Nonproliferation Review* Fall-Winter 2000 edition, pp. 136-145, 2000, http://cns.miis.edu/npr/pdfs/73schmi.pdf
- Nuclear Weapons Free-Zones at a Glance, *Arms Control Today*, http://www.armscontrol.org/factsheets/nwfz
- UN Security Council Resolution 1540, http://www.un.org/en/ga/search/view_doc.asp?symbol=S/RES/1540%20(2004)

Syllabus

- Proliferation Security Initiative, http://www.fas.org/sgp/crs/nuke/RS21881.pdf

Basic physics and technology of the nuclear fuel cycle

- Robert F. Mozley, *The Politics and Technology of Nuclear Proliferation*, University of Washington Press, 1998.
- The Nuclear Fuel Cycle, World Nuclear Organization, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/nuclear-fuel-cycle-overview.aspx
- Uranium Enrichment, Wikipedia, http://en.wikipedia.org/wiki/Enriched_uranium
- Spent Fuel Reprocessing, Wikipedia, http://en.wikipedia.org/wiki/Nuclear_reprocessing
- Status and trends in spent fuel reprocessing, IAEA, http://www-pub.iaea.org/MTCD/publications/PDF/te_1467_web.pdf

Links between nuclear technology and proliferation

- Stephen M. Meyer, *The Dynamics of Nuclear Proliferation*, University of Chicago Press, 1984.
- Scott D. Sagan and Kenneth N. Waltz, *The Spread of Nuclear Weapons*, W. W. Norton & Company, 2003.
- William C. Potter, *Nuclear Power and Nonproliferation*, Oelgeschlager, Gunn, and Hain, 1982.
- Matthew Bunn, ‘‘Civilian Nuclear Energy and Nuclear Weapons Programs: The Record,’’ International Topical Workshop on Proliferation-Resistance in Innovative Reactors and Fuel Cycle, International Atomic Energy Agency (IAEA), Como, Italy, July 26, 2001.
- Man-Sung Yim, “Nuclear nonproliferation and the future expansion of nuclear power,” *Progress in Nuclear Energy* Vol. 48, pp. 504-524, 2006.

Role of technology in nuclear nonproliferation

- Harold Feiveson, ‘‘Proliferation Resistant Nuclear Fuel Cycles,’’ *Annual Review of Energy* Vol. 3, pp. 357-394, 1978, http://www.annualreviews.org/doi/abs/10.1146/annurev.eg.03.110178.002041
- Man-Sung Yim, “Nuclear nonproliferation and the future expansion of nuclear power,” *Progress in Nuclear Energy* Vol. 48, pp. 504-524, 2006.

International safeguards

- James Tape and Joseph Pilat, “Nuclear Safeguards and the Security of Nuclear Materials,” *Nuclear Safeguards, Security and Nonproliferation: Achieving Security with Technology and Policy*, James Doyle editor, Elsevier, 2008.
- Gary T. Gardener, *Nuclear Nonproliferation, A Primer*, Lynne Rienner, 1994

Materials control and accountability

- Brian Boyer and Mark Schanfein, “International Safeguards Inspection: An Inside Look at the Process,” *Nuclear Safeguards, Security and Nonproliferation: Achieving Security with Technology and Policy*, James Doyle editor, Elsevier, 2008.

Physical security

- Mary Lynn Garcia, “Physical Protection,” *Nuclear Safeguards, Security and Nonproliferation: Achieving Security with Technology and Policy*, James Doyle editor, Elsevier, 2008.
- Mary Lynn Garcia, *The Design and Evaluation of Physical Protection Systems*, Elsevier, 2008.

Syllabus

Nuclear material measurement technologies

- Douglas Reilly and Nobert Ensslin, "Nuclear Material Measurement Technologies," *Nuclear Safeguards, Security and Nonproliferation: Achieving Security with Technology and Policy*, James Doyle editor, Elsevier, 2008.

Statistical methods in nuclear nonproliferation

- Tom Burr, "Statistical Methods in Nuclear Nonproliferation," *Nuclear Safeguards, Security and Nonproliferation: Achieving Security with Technology and Policy*, James Doyle editor, Elsevier, 2008.

Role of policy in nuclear nonproliferation

- Jordan, W. J. Taylor, and M. J. Mazarr, *American National Security*, 5th ed., Johns Hopkins Press, 1999.
- George P. Schultz, William J. Perry, Henry A. Kissinger and Sam Nunn, Toward a Nuclear-Free World, http://online.wsj.com/article/SB120036422673589947.html
- G. Perkovich, J. Cirincione, R. Gottemoeller, J.B. Wolfstahl, J.T. Matthews, "Universal Compliance, A Strategy for Nuclear Security," Carnegie Endowment for International Peace, June 2004.