

NRE 6505 – Fundamentals of Nuclear Nonproliferation (Spring 2024)

Instructor: Andrew Hummel, Ph.D.

E-mail: ahummel6@gatech.edu

Office Phone: 404-894-6316

Office Location: Boggs 3-85

Office Hours: M/W 2:00 – 4:00 or by appointment (always best)

I am happy to meet in-person, over the phone, or via Teams or some other platform

Course Description

Nuclear energy offers an attractive solution for current and future energy requirements, including replacement of carbon sources, space exploration, and water desalination needs. However, the peaceful use of nuclear energy opens up a possibility for misuse of technology for weapon development. Under the Nuclear Non-Proliferation Treaty, International Atomic Energy Agency safeguards have “the exclusive purpose of verification of the fulfillment of [the non-nuclear-weapon States’] obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices.” This course explores the fundamentals of nuclear energy generation, pathways of materials misuse, and the implication of nuclear technology for international security and policy.

Prerequisites

None

Course Details

Term: Spring 2024

Course name: Fundamentals of Nuclear Nonproliferation

CRN: 31726

Course number: NRE 6505

Section number: A

Meeting times: Tuesday/Thursday 3:30 pm – 4:45 pm

Room building & number: Boggs 328

Learning Objectives

Upon successful completion of this course, students should be able to:

1. Explain the principles of radiation interactions, radiation detection, power generation based on nuclear processes, nuclear fuel cycle, and other aspects of nuclear science
2. Summarize multiple applications of nuclear technologies in a wide range of disciplines related to nuclear nonproliferation
3. Understand the background and working principles of nonproliferation treaties, UN resolutions, and international law

Textbook

Masterson R.E. (2017) Nuclear Engineering Fundamentals: A Practical Perspective (CRC Press)

Note: this book may be downloaded via the Georgia Tech library

Additional Materials/Resources

R. Knief, Nuclear Criticality Safety: Theory and Practice, American Nuclear Society, 1985

Other books, reviews, and papers indicated in lecture notes and/or posted on Canvas. NOTE: Most lectures use outside sources in addition to (or instead of) the textbook. Canvas will be used as the course website to

communicate with the students.

Grading

Midterm: 20%

Final Exam: 20%

HW & Quizzes: 20%

Course Projects/Papers: 40%

Grade Scale: A: (90-100), B: (80-89), C: (70-79), D: (60-69), F: (0-59)

Attendance Policy

Students are expected to attend all classes for their full length. If a student is unable to attend a class for whatever reason, it is the student's responsibility to acquire any missed notes, lecture materials, or other information disseminated in class. If you know in advance that you will not be able to attend a class, please let me know so that you can avoid getting a zero on an unannounced quiz (see below regarding missed quizzes). Lectures will be recorded via Microsoft Teams and posted to Canvas, however, audio and/or video issues inevitably arise (so don't rely on these).

I do NOT DISTRIBUTE my personal notes, lecture materials, or problem solutions, so if you miss class you must get this information from another student.

Homework

Regarding late work: I realize that unforeseen events happen and situations arise. Late work can be turned in within 24 hours of the due date for a maximum grade of 50%. The assignment will not be accepted after 24 hours from the due date and will receive a zero. However, there are times when I will review the homework within this 1-day window. If this happens, then I can no longer accept the assignment, and it will automatically receive a zero. Obviously, there are exceptions at my discretion, but if something comes up that hinders you from turning in the HW on time, the earlier you let me know the better chance I can accommodate you.

Note that homework is **sometimes** graded on **effort & completeness**, rather than accuracy. Thus, it is usually in your best interest to submit an incomplete assignment on time, rather than a complete assignment late. Homework should be submitted at the start of class unless an instant arises where an electronic copy can be submitted to **Canvas** or emailed directly to the instructor in PDF format.

Quizzes

Quizzes will be given throughout the term either in-person or via **Canvas**. In-person quizzes will not be announced. If the quiz is given online, then you will have a certain time window (usually a few days) to complete the quiz. I will alert the class when a quiz has been posted, and once a quiz has been made available, I highly encourage you to take it at your earliest availability rather than wait. Note that I have **never extended** a quiz for an individual who simply forgot to take it.

The time allotted for all quizzes is short, generally about 15-20 minutes. Although the quiz will close on Canvas after the allotted time, you can still submit any work you have done for partial credit (and I highly encourage this). However, the submitted work must align with any answers you have submitted, thus you **must submit something** to Canvas in order to receive partial credit. If what you submit to Canvas does not align with work that you submit, this amounts to cheating (see Cheating & Honor Code below). A student can always choose to come to my office and take a quiz in-person rather than online, but you must request this in a timely manner in order to ensure instructor availability.

Homework and quiz assignments will be given **EQUAL** weight in final grading

Course Projects/Papers

Several projects will be given this term, and details will be given out later since the exact nature of the projects may vary depending on how the semester unfolds. If the project includes a presentation, all students are expected to be present for **ALL** project presentations. **ALL** students must be present for in-class time devoted to the projects (which will be during the lab time). Students not present at the time when **THEIR** presentation is supposed to be given can receive a maximum project grade of no more than 50%. Students not present at the time when **OTHER** presentations are supposed to be given will receive a 5% deduction from their final project grade for each presentation they miss. The student must make arrangements with the instructor prior to the project presentation dates to receive an excused absence. Project presentations will take place throughout the term.

Tests and Final Exam

All students are expected to be present at the time exams are given. Students not present at the time when an exam is given will receive a “0” for that exam. No make-up exams will be given unless the student makes arrangements with the instructor prior to the exam date to receive an excused absence. The students will be informed when an exam will take place at least one week before the exam. The format for the tests and the final will be explained at this time.

Extra Credit

Certain homework and exams may have extra credit problems that the student can choose to perform if they wish. There will NOT be an extra credit assignment.

Cheating & Honor Code

Students are expected to abide by all policies set by the instructor regarding what is permitted and what is not permitted for all assignments. Unless explicitly stated otherwise, students must **always** abide by the following:

- Homework: students can work alone or in groups, but each student must submit only their individual work. Copying is never allowed.
- Quizzes: students must work alone. Students cannot seek outside assistance and can only ask the instructor for guidance/help.
- Tests/Final: students must work alone. Students cannot seek outside assistance and can only ask the instructor for guidance/help.

Outside assistance includes utilization of websites and other tools. If you are unsure of something, just ask. Violation of any of the above will constitute a “0” grade on the assignment as well as notification of the College Dean and Department Head.

The Honor Code can be found at: <http://www.honor.gatech.edu>

Course Outline

Week	Description
1	Introduction; history of nuclear science; nuclear overview
2	Basic physics; atoms and nuclei
3	Nuclear stability; radioactivity and radioactive decay
4	Neutron interactions; cross sections; reaction rates
5	Transmutations; attenuation; fission & fusion
6	Photon interactions; cross sections; reaction rates; attenuation
7	Dosimetry & shielding
8	Midterm
9	Radiation detection technologies overview; gamma and x-ray spectroscopy
10	Neutron detection; imaging and active interrogation
11	Reactor design and nuclear fuel cycle proliferation concerns
12	History & design of nuclear weapons
13	Nuclear Nonproliferation Treaty; nuclear terrorism and international law
14	Deterrence and safeguards; nuclear security
15	Principles of nuclear forensics and CTBT; verification methods and technologies
16	Course presentations; course review
	Comprehensive Final Exam (TBD)

The above schedule is tentative, and subject to change at any time.

Additional Information

GT Policy on Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodations, contact the Office of Disability Services at (404) 894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodation letter. Please also e-mail me as soon as possible to set up a time to discuss your learning needs.

GT Policy on Excused Absences for Religious Observances

Georgia Tech policy on excused absences for religious observances: <http://www.catalog.gatech.edu/rules/4/>: “Students who are absent because of participation in a particular religious observance will be permitted to make up the work missed during their absence with no late penalty, provided the student informs the course instructor of the upcoming absence, in writing, within the first two weeks of class, and provided the student makes up the missed material within the timeframe established by the course instructor.”

GT Policy on Absences for Medical Reasons

GT policy on absences for medical reasons. <http://www.catalog.gatech.edu/rules/4/> Students will work with the Office of VP for Student Life (Dean of Students) to have them verify that the student was ill 3 and to determine the severity of the problem; the Dean’s office will then interact with the instructor(s) if necessary. To the extent possible, requests from the Office of the Dean of Students to excuse a medical emergency or illness and allow make-up of the work missed, including homework, examinations, or other class assignments will be accommodated.

Policy on Unforeseen or Emergency Situations

If due to an unfortunate unplanned emergency such as a car accident, a theft or burglary in your apartment, you are unable to attend an exam at the last minute, a police report substantiating the accident or mishap must be provided. Requests for accommodating an absence that are made after the exam will under almost all circumstances, without the above documentation, not be honored. Under the unlikely and highly discouraged

event that you have to miss the final exam, alternate arrangements will be made on a case-by-case basis, including, but not limited to, a one-on-one oral exam of appropriate duration, to test your knowledge in the subject matter.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See <http://www.catalog.gatech.edu/rules/22/> for an articulation of some basic expectation that you can have of faculty and that faculty have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, we encourage you to remain committed to the ideals of Georgia Tech while in this class.

Campus Resources for Students

The CARE Center and the Counseling Center, Stamps Health Services, and the Dean of Students Office will offer both in-person and virtual appointments. Student Center services and operations are available on the Student Center website. For more information on these and other student services, contact the Dean of Students or the Division of Student Life.

Mental Health & Wellness

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, depression, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. GT offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know is experiencing any of the issues noted above, consider utilizing the confidential mental health services available on campus. I encourage you to reach out to GT CARE (www.care.gatech.edu, 404-894-3498) or the Counseling Center (www.counseling.gatech.edu, 404-894-2575) for support. An on-campus counselor or after-hours services are available to assist you.